DOCUMENT RESUME

ED 303 355 SE 050 340

TITLE	Eighth Grade Earth Science Curriculum Guide. Part 1.
INSTITUTION	New York City Board of Education, Brooklyn, N.Y. Div. of Curriculum and Instruction.
REPORT NO	Curric-00-8030-30; ISBN-1-55839-058-8
PUB DATE	88
NOTE	330p.; Drawings may not reproduce well. Working draft.
AVAILABLE FROM	New York City Board of Education, Curriculum Editorial and Production Unit, Office of Curriculum Development and Support, 131 Livingston Street, Room 613, Brooklyn, NY 11201 ($10.00).
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Curriculum Enrichment; Curriculum Guides; *Earth Science; Geology; Instructional Improvement; *Instructional Materials; Junior High Schools; Motivation Techniques; Physical Sciences; *Problem Solving; *Science Activities; Science Curriculum; Science Instruction; *Secondary School Science

ABSTRACT

This is a curriculum guide composed of lessons which can serve as models for the beginning teacher as well as for the teacher who needs activities to broaden the earth science perspective in the classroom. It was designed to supplement the New york State Earth Science Syllabus and encourages students to develop inquiry and problem solving skills. This working draft has four units. Unit I deals with matter: its definition; the building blocks; differences between metals and nonmetals; combination of elements; and the differences between mixtures and compounds. Unit II discusses geology: the materials making up the earth's crust; the earth's surface; rocks; the geologic record and mapping; and plate tectonics. Unit III concentrates on oceanography: the features along the continental coastlines; ocean basins; salinity; waves; and the ocean's resourcefulness. Unit IV includes weather and climate: a definition of weather; effects of air masses and fronts; characteristics of high and low pressure areas; wave cyclones; forcasting the weather; layers and composition of the atmosphere; and the factors influencing climate. This guide outlines objectives and process skills which cover planning and design, performance, analysis, interpretation, and application. Lesson plans and reproducible sheets are provided for teacher use. (RT)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED303355

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☒ This document has been reproduced as received from the person or organization originating it
☐ Minor changes have been made to improve reproduction quality
- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY
Alaire Mitchell
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

8

EIGHTH GRADE
EARTH SCIENCE

CURRICULUM GUIDE

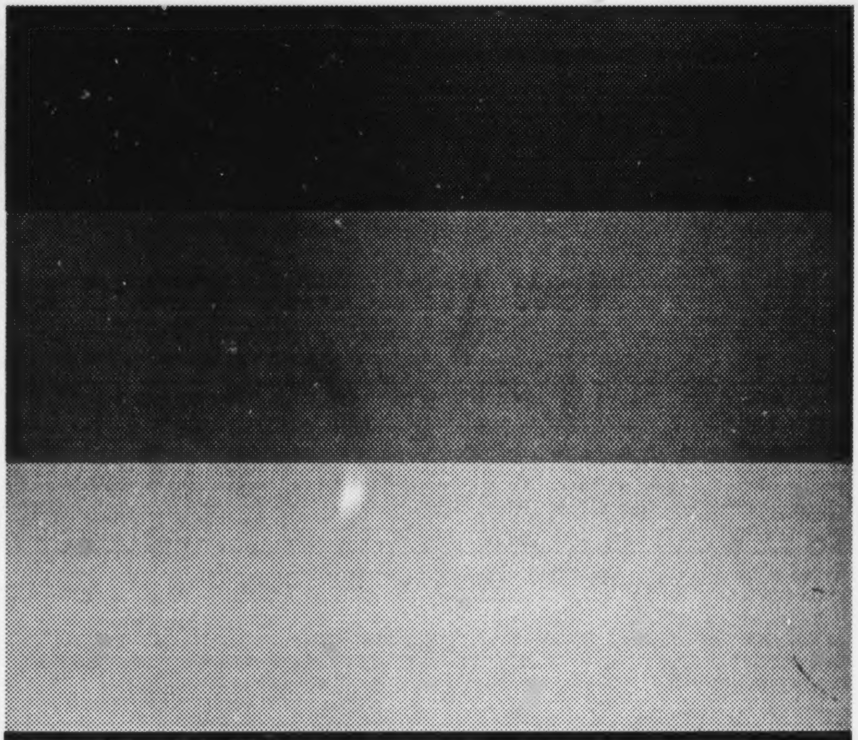
PART 1

SE 050 340

New York City Board of Education

Division of Curriculum and Instruction - Office of Curriculum Development and Support

8



EIGHTH GRADE
EARTH SCIENCE

CURRICULUM GUIDE

PART 1

New York City Board of Education

Division of Curriculum and Instruction - Office of Curriculum Development and Support

New York City Board of Education

Robert F. Wagner, Jr., President
Dr. Irene H. Impellizzeri, Vice President

Dr. Gwendolyn C. Baker
Amalia V. Betanzos
Dr. Stephen R. Franse
James F. Regan
Edward L. Sadowsky

Dr. Richard R. Green
Chancellor

Dr. Bruce E. Williams
Deputy Chancellor

Dr. Dolores M. Fernandez
Deputy Chancellor for Instruction and Development

Dr. Harvey Robins
Deputy Chancellor for Financial Affairs

Division of Curriculum and Instruction

Pearl M. Warner
Executive Director *(Acting)*

Dr. Morris Freedman
Administrative Assistant Superintendent *(Acting)*

Rose McKenna
Deputy Executive Director *(Acting)*

Anthony Galitsis
Director of Science

Alaire Mitchell
Assistant Director of Curriculum Research

Copyright 1988
by the Board of Education of the City of New York

Application for permission to reprint any section of this material should be made to the Chancellor, 110 Livingston Street, Brooklyn, NY 11201. Reprint of any section of this material shall carry the line, "Reprinted from *Eighth Grade Earth Science—Part 1* by permission of the Board of Education of the City of New York."

New York City public schools should order additional copies of this publication from the Bureau of Supplies.

ISBN #1-55839-058-8 Curriculum No. 00-8030-30

Other persons and institutions may obtain copies of this publication from the Curriculum Editorial and Production Unit of the Office of Curriculum Development and Support, Room 613, 131 Livingston Street, Brooklyn, NY 11201. See current catalog for price. For information, call (718) 935-3990.

FOREWORD

This working draft of Eighth Grade Earth Science--Part One is being offered for reactions from science educators throughout the city. It has been designed to conform to the State Syllabus, and encourages students to develop inquiry and problem solving skills.

The lessons can serve both as models for the inexperienced teacher and as points of departure for the more practiced teacher. It is not our aim that all teachers in all classes teach the material in the same way, or even in the same sequence. These lesson guides represent a synthesis of several points of view, and demonstrate one way in which the objectives of the science curriculum can be implemented.

We hope this guide will enable teachers to think more creatively about earth science and its role in helping students to develop scientific literacy.

Pearl M. Warner

Pearl M. Warner
Executive Director (Acting)
Division of Curriculum and Instruction

ACKNOWLEDGMENTS

This working draft of Eighth Grade Earth Science--Part One is a project of the Division of Curriculum and Instruction, Pearl M. Warner, Executive Director (Acting); Morris Freedman, Administrative Assistant Superintendent (Acting).

Overall supervision was provided by Anthony A. Galitsis, Director of Science, and John Kominski, Assistant Director of Science.

Principal writers of the guide were Julius Kahn, Teacher of Science, JHS 168, CSD #25; Alice Kasten, Teacher of Science, JHS 67, CSD #26; Gerald Lesperance, Teacher of Science, Francis Lewis HS; James Lucarelli, Staff Developer-IS/JHS, CSD #19; William Moore, Director of the Science Exploration and Experimentation Center, CSD #22.

Ongoing review and revision was coordinated by Mary L. DeMarco-Keating, Science Associate; Ira B. Kanis, Assistant to the Director; and Joseph J. Saccente, Science Associate.

Additional material was contributed by Edward Denecke, Teacher Trainer, Science Technical Assistance Center-Queens, and Seymour Rifkin, Teacher of Science, JHS 104, CSD #2.

The guide was prepared for publication by the Editorial Production Unit, Alaire Mitchell, Assistant Director of Curriculum Research; Maureen Maguire, Production Coordinator; Sarah Corbin, Copy Chief.

The manuscript was edited by Eileen Fitzpatrick, Sally S. Grimm, and Deborah Posner. Eileen Fitzpatrick produced the guide. Word processing services were provided by Pat DePalo, Anna Marie Parasole, and Clemente Pierre. Many of the diagrams were drawn by Heidi Lanino. The cover was designed by Brian Garrigan.

INTRODUCTION

The contents of this working draft of the Eighth Grade Earth Science curriculum have been designed to guide the teacher in the presentation of the materials found in New York State Earth Science Block D--The Earth's Changing Surface, Block E--Weather and Climate, and Block F--Astronomy and Aerospace Science. Many lessons have references to core objectives from Block J--Science, Technology and Society. These core objectives have been infused into the lessons dealing with Blocks D, E, and F.

In addition to the core objectives, the New York State RCT in science also examines process skills in the content areas. These process skills cover three major areas: (1) planning and design; (2) performance; (3) analysis, interpretation and application. An inquiry approach has been adopted in the design of the lessons so that students can be given maximum exposure to process skills. Teachers are encouraged to direct their students in:

- Recognizing and stating a problem;
- Solving problems;
- Developing a hypothesis;
- Designing procedures for testing a hypothesis;
- Making observations and interpreting data;
- Forming conclusions and making generalizations.

TABLE OF CONTENTS

UNIT I

1. The nature of matter 1
2. The building blocks of matter 4
3. The properties of elements 8
4. Elements combine with each other 13
5. Properties of mixtures 16

UNIT II

SECTION A

1. The nature of minerals 19
2. The major groups of minerals 22
3. Minerals can be identified by their properties 24
4. Minerals as natural resources 29
5. The composition of the earth 33

SECTION B

1. The formation of igneous rocks 35
2. Identifying igneous rocks 38
3. Formation of sedimentary rocks 41
4. Identification of sedimentary rocks 45
5. Formation and identification of metamorphic rocks 49
6. The rock cycle 53

SECTION C

1. Surface features of the earth 56
2. Changes in the earth's surface 59
3. Mechanical weathering 62
4. Chemical weathering 65
5. Formation of caves 70
6. Erosion 73
7. Erosion by running water 76
8. Groundwater 79
9. The water cycle 82
10. Life cycle of a river 86
11. Glacial erosion 90
12. Wind erosion 94
13. Soil formation 97
14. Prevention of erosion 101

SECTION D

1. The rock record 104
2. Relative age of rocks 106
3. Absolute age of rocks 112
4. Fossils (Part 1) 121
5. Fossils (Part 2) 125
6. Fossil fuels 128
7. The geological record 131

SECTION E

1. Continental drift 135
2. Mountain formation 140
3. Volcanoes 144
4. Earthquakes 148
5. Plate tectonics 152

SECTION F

1. Geologic history of New York City 157
2. Topographic maps 163

UNIT III

1. Coastal features 169
2. Origin of the ocean basins (continental drift) 176
3. Ocean floors and underwater topography 182
4. Ocean water 189
5. Seawater in motion 195
6. Beach/seacliff terrace formation--erosive action 198
7. Currents 203
8. Oceans as a resource 211

UNIT IV

1. Weather 213
2. Air masses 216
3. Station model 220
4. High-pressure areas 224
5. Low-pressure areas 229
6. Fronts 231
7. Wave cyclones 234
8. Weather elements 237
9. Atmospheric pressure and temperature 241
10. Moisture in the atmosphere 244
11. Weather forecasting 248
12. Composition of the atmosphere 251
13. Layers in the atmosphere 254
14. Atmospheric pollution 257
15. Energy in the atmosphere 260
16. Air movements 263
17. Wind patterns 266
18. Local winds 271
19. Cloud formation and precipitation 275
20. Climate: a definition 280
21. General types of climate 284
22. Effect of global winds on climate 286
23. Factors affecting temperature 289
24. Factors affecting moisture 293
25. Climate of New York State 296

SUGGESTED TERM CALENDAR

UNIT I: MATTER

1. What is matter?

2. What are the building blocks of matter?

3. How can we tell the difference between metals and nonmetals?

4. What happens when elements combine?

5. How do mixtures differ from compounds?

6. UNIT TEST: MATTER

UNIT II: GEOLOGY

SECTION A: MINERALS

7. What materials make up the earth's crust?

8. What are the major groups of minerals?

9. How can we identify a mineral?

10. Which minerals are important to humans?

11. How can we conserve natural resources?

12. SUB-UNIT TEST: MINERALS

SECTION B: ROCKS

13. How do igneous rocks form?

14. How can we identify igneous rocks?

15. How do sedimentary rocks form?

16. How can sedimentary rocks be identified?

17. How do metamorphic rocks form and how can they be identified?

18. What is the rock cycle?

19. SUB-UNIT TEST: ROCKS

SECTION C: THE EARTH'S SURFACE

20. What are the major landforms on the surface of the earth?

21. What causes the earth's surface to change?

22. How does the earth's surface weather physically?

23. What is chemical weathering?

24. How are caves formed?

25. What is erosion?

26. How does water erode the surface of the earth?

27. SUB-SECTION TEST

28. What influences the rate of infiltration of groundwater?

29. What is the water cycle?

30. How does a river valley develop?

31. How have glaciers changed the surface of the earth?

32. How does wind change the surface of the earth?

33. How is soil formed?

34. How can we control erosion?

35. SUB-UNIT TEST: THE EARTH'S SURFACE

SECTION D: THE GEOLOGIC RECORD

36. What is the rock record?

37. How can we tell the relative age of rocks?

38. How can we determine the absolute age of a rock?

39. What is a fossil? (Part 1)

40. What is a fossil? (Part 2)

41. Why are petroleum, coal, and natural gas called fossil fuels?

42. What does the rock record suggest about geologic history?

SUB-UNIT TEST: THE GEOLOGIC RECORD

SECTION E: PLATE TECTONICS

43. What is the continental drift theory?

44. What forces build up the earth's crust?

45. How has volcanism changed the earth's surface?

46. What causes earthquakes?

47. What is the theory of plate tectonics?

48. SUB-UNIT TEST: PLATE TECTONICS

SECTION F: GEOLOGIC MAPPING

49. Why does New York City have such a varied landscape?

50. How can we construct and interpret a topographic map?

SUB-UNIT TEST: GEOLOGIC MAPPING

UNIT III: OCEANOGRAPHY

51. What features are found along continental coastlines?

52. How did the ocean basins originate?

53. How can scientists obtain a profile of the ocean floor?

54. Why are the oceans salty?

55. How are waves formed?

56. What happens at the land-sea interface?

57. What causes the movements of ocean currents?

58. How are the oceans used as a resource?

59. UNIT TEST: OCEANOGRAPHY

UNIT IV: WEATHER AND CLIMATE

60. What is meant by the term weather?

61. How is weather affected by air masses?

62. How can we show the weather on a station model?

63. What are the characteristics of high-pressure areas?

64. What are the characteristics of low-pressure areas?

65. How do fronts affect our weather?

66. What type of weather is associated with a wave cyclone?

67. What are the elements of weather?

68. How are air temperature and air pressure related?

69. How does water get into the atmosphere?

70. How can we forecast the weather?

71. SUB-UNIT TEST: WEATHER

72. What is the composition of the atmosphere?

73. What are the characteristics of the layers of the atmosphere?

74. What determines whether or not a substance is an air pollutant?

75. How is the atmosphere heated?

76. How do convection and radiation explain the movement of air in the atmosphere?

77. How does the air circulate around the world?

78. What causes some local winds?

79. How are clouds/fog formed?

80. SUB-UNIT TEST: THE ATMOSPHERE

81. How does a desert climate affect the plants and animals that live there?

82. What factors influence climate?

83. What are the effects of the global winds on climate?

84. What factors affect the temperature of a location?

85. How can two cities with the same coordinates have different amounts of precipitation?

86. What is the climate of New York State?

87. UNIT TEST: WEATHER AND CLIMATE

UNIT I

		LESSON NUMBER				
		1	2	3	4	5
1.0	Planning and Design	●		●	●	●
1.1	Formulates a question or defines a problem to be investigated (8)				●	
1.2	**Predicts an experimental result (9) ***			●	●	●
1.3	Formulates a hypothesis to be tested in an investigation (9)			●	●	●
1.4	**Designs an observation or measurement procedure (3)**	●				●
1.5	**Designs a controlled experiment (10, 11)**				●	
2.0	Performance	●	●	●	●	●
2.1a	**Carries out a qualitative observation (1, 7)**	●	●	●	●	●
2.1b	**Carries out a quantitative observation or measurement (1, 5, 7)**	●	●	●		●
2.2	**Manipulates apparatus safely; develops technique (4, 6)**	●		●		
2.3	**Records results; describes observations (2)**	●	●	●	●	●

* Boldface type indicates the core process skills which will be tested on the Regents competency test in science.

UNIT I

		LESSON NUMBER 1	2	3	4	5
2.4	Performs numeric calculations					
2.5	Explains or makes a decision about experimental technique	●	●	●	●	
2.6	Works according to own design					
3.0	Analysis, Interpretation, and Application	●	●	●	●	●
3.1a	Transforms results into a standard form (other than graphs), such as a data table where the form is given (12, 13)	●		●		
3.1b	Graphs data, given numbered axes (12, 13)					
3.2a	Determines a qualitative relationship (13, 14)	●	●	●	●	●
3.2b	Determines a quantitative relationship (13, 14, 15)	●	●	●		●
3.3	Determines accuracy of experimental data (16)					
3.4	Defines or discusses limitations and/or assumptions that underlie the experiment (16, 22)					
3.5	Formulates or proposes a generalization or model (17, 18, 19)	●		●	●	●
3.6a	Interprets data in graphs, tables, and diagrams (14)	●		●		
3.6b	Explains a relationship (17, 20)	●	●	●	●	●
3.7	Formulates new questions or defines a new problem based on the results of the investigation					
3.8	Predicts based on the results of the investigation (9)	●		●	●	

UNIT II

	LESSON NUMBER A 1	A 2	A 3	A 4	A 5	B 1	B 2	B 3	B 4	B 5	B 6	C 1	C 2	C 3	C 4	C 5	C 6	C 7	C 8	C 9		
1.0 Planning and Design		●	●		●	●		●		●	●		●		●			●	●			
1.1 Formulates a question or defines a problem to be investigated (8)			●		●	●		●		●	●				●							
1.2 Predicts an experimental result (9) *		●						●		●	●		●		●			●	●			
1.3 Formulates a hypothesis to be tested in an investigation (9)			●			●									●				●			
1.4 Designs an observation or measurement procedure (3)						●		●		●	●				●							
1.5 Designs a controlled experiment (10, 11)						●									●							
2.0 Performance	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		
2.1a Carries out a qualitative observation (1, 7)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		
2.1b Carries out a quantitative observation or measurement (1, 5, 7)	●		●	●		●	●		●	●					●				●			
2.2 Manipulates apparatus safely; develops technique (4, 6)			●			●	●	●	●	●	●				●				●			
2.3 Records results; describes observations (2)	●		●	●		●	●	●	●	●		●	●		●		●	●	●	●		

* Boldface type indicates the core process skills which will be tested on the Regents competency test in science.

U N I T II

	LESSON NUMBER																					
	C 10	C 11	C 12	C 13	C 14	D 1	D 2	D 3	D 4	D 5	D 6	D 7	E 1	E 2	E 3	E 4	E 5	F 1	F 2			
1.0 Planning and Design		●		●	●	●		●			●	●		●	●	●		●	●			
1.1 Formulates a question or defines a problem to be investigated (8)					●																	
1.2 Predicts an experimental result (9) *		●		●	●	●		●			●	●		●		●		●				
1.3 Formulates a hypothesis to be tested in an investigation (9)				●		●		●				●			●	●						
1.4 Designs an observation or measurement procedure (3)				●		●		●				●							●			
1.5 Designs a controlled experiment (10, 11)				●								●										
2.0 Performance	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			
2.1a Carries out a qualitative observation (1, 7)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			
2.1b Carries out a quantitative observation or measurement (1, 5, 7)	●	●		●	●			●				●							●			
2.2 Manipulates apparatus safely; develops technique (4, 6)				●				●	●			●							●			
2.3 Records results; describes observations (2)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			

* Boldface type indicates the core process skills which will be tested on the Regents competency test in science.

UNIT II

		LESSON NUMBER																			
		A 1	A 2	A 3	A 4	A 5	B 1	B 2	B 3	B 4	B 5	B 6	C 1	C 2	C 3	C 4	C 5	C 6	C 7	C 8	C 9
2.4	Performs numeric calculations										●					●				●	
2.5	Explains or makes a decision about experimental technique			●			●		●	●						●				●	
2.6	Works according to own design			●								●									
3.0	Analysis, Interpretation, and Application	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
3.1a	Transforms results into a standard form (other than graphs), such as a data table where the form is given (12, 13)		●	●		●		●		●	●									●	
3.1b	Graphs data, given numbered axes (12, 13)																			●	
3.2a	Determines a qualitative relationship (13, 14)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
3.2b	Determines a quantitative relationship (13, 14, 15)	●		●	●	●	●	●		●	●					●			●	●	
3.3	Determines accuracy of experimental data (16)																				
3.4	Defines or discusses limitations and/or assumptions that underlie the experiment (16, 22) ·							●				●				●					
3.5	Formulates or proposes a generalization or model (17, 18, 19)					●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
3.6a	Interprets data in graphs, tables, and diagrams (14)	●	●	●	●	●		●	●	●	●		●	●						●	
3.6b	Explains a relationship (17, 20)		●		●	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●
3.7	Formulates new questions or defines a new problem based on the results of the investigation					●															
3.8	Predicts based on the results of the investigation (9)			●				●	●	●	●			●		●		●	●	●	

UNIT II

		LESSON NUMBER																					
		C 10	C 11	C 12	C 13	C 14	D 1	D 2	D 3	D 4	D 5	D 6	D 7	E 1	E 2	E 3	E 4	E 5	F 1	F 2			
2.4	Performs numeric calculations				●				●														
2.5	Explains or makes a decision about experimental technique								●											●			
2.6	Works according to own design																						
3.0	Analysis, Interpretation, and Application	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			
3.1a	**Transforms results into a standard form (other than graphs), such as a data table where the form is given (12, 13)**				●				●														
3.1b	**Graphs data, given numbered axes (12, 13)**				●				●														
3.2a	**Determines a qualitative relationship (13, 14)**	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			
3.2b	**Determines a quantitative relationship (13, 14, 15)**	●	●		●	●			●				●							●			
3.3	Determines accuracy of experimental data (16)								●														
3.4	Defines or discusses limitations and/or assumptions that underlie the experiment (16, 22) ·								●														
3.5	Formulates or proposes a generalization or model (17, 18, 19)		●	●	●	●	●	●	●	●		●		●	●		●	●		●			
3.6a	**Interprets data in graphs, tables, and diagrams (14)**	●	●	●	●			●	●	●		●	●	●	●	●	●	●	●	●			
3.6b	**Explains a relationship (17, 20)**		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			
3.7	Formulates new questions or defines a new problem based on the results of the investigation								●														
3.8	**Predicts based on the results of the investigation (9)**				●	●	●		●			●	●		●		●		●				

UNIT III

		LESSON NUMBER							
		1	2	3	4	5	6	7	8
1.0	Planning and Design	●			●	●		●	●
1.1	Formulates a question or defines a problem to be investigated (8)								●
1.2	**Predicts an experimental result (9)** *	●				●		●	
1.3	Formulates a hypothesis to be tested in an investigation (9)								
1.4	**Designs an observation or measurement procedure (3)**				●				●
1.5	**Designs a controlled experiment (10, 11)**								
2.0	Performance	●	●	●	●	●	●	●	●
2.1a	**Carries out a qualitative observation (1, 7)**	●	●	●	●	●	●	●	●
2.1b	**Carries out a quantitative observation or measurement (1, 5, 7)**			●	●				
2.2	**Manipulates apparatus safely; develops technique (4, 6)**			●	●			●	
2.3	**Records results; describes observations (2)**	●	●	●	●	●	●	●	●

* Boldface type indicates the core process skills which will be tested on the Regents competency test in science.

UNIT III

	LESSON NUMBER	1	2	3	4	5	6	7	8
2.4	Performs numeric calculations			●	●				
2.5	Explains or makes a decision about experimental technique			●	●			●	
2.6	Works according to own design								
3.0	Analysis, Interpretation, and Application	●	●	●	●	●	●	●	●
3.1a	Transforms results into a standard form (other than graphs), such as a data table where the form is given (12, 13)			●	●				
3.1b	Graphs data, given numbered axes (12, 13)								
3.2a	Determines a qualitative relationship (13, 14)	●	●	●	●	●	●	●	●
3.2b	Determines a quantitative relationship (13, 14, 15)			●	●				
3.3	Determines accuracy of experimental data (16)								
3.4	Defines or discusses limitations and/or assumptions that underlie the experiment (16, 22)			●					
3.5	Formulates or proposes a generalization or model (17, 18, 19)		●	●	●	●	●		
3.6a	Interprets data in graphs, tables, and diagrams (14)	●	●	●	●	●	●	●	●
3.6b	Explains a relationship (17, 20)	●	●	●		●	●	●	
3.7	Formulates new questions or defines a new problem based on the results of the investigation			●		●			
3.8	Predicts based on the results of the investigation (9)	●				●		●	

UNIT IV

	LESSON NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13									
1.0 **Planning and Design**	●	●					●	●	●	●	●											
1.1 Formulates a question or defines a problem to be investigated (8)									●													
1.2 Predicts an experimental result (9) *	●	●					●	●	●		●											
1.3 Formulates a hypothesis to be tested in an investigation (9)																						
1.4 Designs an observation or measurement procedure (3)								●	●	●												
1.5 Designs a controlled experiment (10, 11)							●			●												
2.0 **Performance**	●	●	●	●	●	●	●	●	●	●	●	●	●									
2.1a Carries out a qualitative observation (1, 7)	●	●	●	●	●	●	●	●	●	●	●	●	●									
2.1b Carries out a quantitative observation or measurement (1, 5, 7)	●	●		●	●			●	●	●		●										
2.2 Manipulates apparatus safely; develops technique (4, 6)								●		●												
2.3 Records results; describes observations (2)	●	●	●	●	●	●	●	●	●	●	●	●	●									

* Boldface type indicates the core process skills which will be tested on the Regents competency test in science.

UNIT IV

	LESSON NUMBER 14	15	16	17	18	19	20	21	22	23	24	25
1.0 Planning and Design						●			●	●		
1.1 Formulates a question or defines a problem to be investigated (8)									●			
1.2 **Predicts an experimental result (9)** *						●						
1.3 Formulates a hypothesis to be tested in an investigation (9)						●				●		
1.4 **Designs an observation or measurement procedure (3)**						●				●		
1.5 **Designs a controlled experiment (10, 11)**						●				●		
2.0 Performance	●	●	●	●	●	●	●	●	●	●	●	●
2.1a **Carries out a qualitative observation (1, 7)**	●	●	●	●	●	●	●	●	●	●	●	●
2.1b **Carries out a quantitative observation or measurement (1, 5, 7)**	●	●			●	●				●		
2.2 **Manipulates apparatus safely; develops technique (4, 6)**						●						
2.3 **Records results; describes observations (2)**	●	●		●	●	●	●	●	●	●	●	●

* Boldface type indicates the core process skills which will be tested on the Regents competency test in science.

UNIT IV

	LESSON NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13
2.4 Performs numeric calculations										●			
2.5 Explains or makes a decision about experimental technique													
2.6 Works according to own design													
3.0 Analysis, Interpretation, and Application	●	●	●	●	●	●	●	●	●	●	●	●	●
3.1a Transforms results into a standard form (other than graphs), such as a data table where the form is given (12, 13)		●						●					
3.1b Graphs data, given numbered axes (12, 13)													
3.2a Determines a qualitative relationship (13, 14)	●	●	●	●	●	●	●	●	●	●	●	●	●
3.2b Determines a quantitative relationship (13, 14, 15)	●	●	●	●	●			●		●	●	●	
3.3 Determines accuracy of experimental data (16)								●					
3.4 Defines or discusses limitations and/or assumptions that underlie the experiment (16, 22)													
3.5 Formulates or proposes a generalization or model (17, 18, 19)		●	●	●	●	●	●	●					
3.6a Interprets data in graphs, tables, and diagrams (14)	●	●	●	●	●	●	●	●	●	●	●		●
3.6b Explains a relationship (17, 20)		●	●	●	●	●	●	●	●	●	●	●	●
3.7 Formulates new questions or defines a new problem based on the results of the investigation													
3.8 Predicts based on the results of the investigation (9)	●	●					●	●	●		●		

UNIT IV

	LESSON NUMBER	14	15	16	17	18	19	20	21	22	23	24	25										
2.4	Performs numeric calculations																						
2.5	Explains or makes a decision about experimental technique																						
2.6	Works according to own design																						
3.0	Analysis, Interpretation, and Application	●	●	●	●	●	●	●	●	●	●	●	●										
3.1a	Transforms results into a standard form (other than graphs), such as a data table where the form is given (12, 13)		●			●	●						●										
3.1b	Graphs data, given numbered axes (12, 13)						●																
3.2a	Determines a qualitative relationship (13, 14)	●	●	●	●	●	●	●	●	●	●	●	●										
3.2b	Determines a quantitative relationship (13, 14, 15)	●	●			●	●				●												
3.3	Determines accuracy of experimental data (16)																						
3.4	Defines or discusses limitations and/or assumptions that underlie the experiment (16, 22) ·																						
3.5	Formulates or proposes a generalization or model (17, 18, 19)		●		●	●	●	●	●		●		●										
3.6a	Interprets data in graphs, tables, and diagrams (14)		●	●	●	●	●	●	●	●	●	●	●										
3.6b	Explains a relationship (17, 20)	●	●	●	●	●	●	●	●	●	●	●	●										
3.7	Formulates new questions or defines a new problem based on the results of the investigation										●												
3.8	Predicts based on the results of the investigation (9)						●				●												

UNIT I

LESSON 1

TOPIC: The nature of matter

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: H7, H8, H13, H14, H16

PROCESS SKILLS: 1, 2, 3, 4, 5, 7, 13

AIM: What is matter?

MATERIALS:

- balance (either equal-arm or triple-beam)
- graduated cylinder
- 3 plastic Ziplock bags
- water (with food coloring)
- block of wood
- Student Worksheet

PERFORMANCE OBJECTIVES: Students will be able to:

- define matter.
- list and give examples of the three phases of matter, i.e., solid, liquid, gas.
- design a model to explain that matter can exist in three different phases depending on the forces between particles.
- deduce that all matter is composed of particles.

MOTIVATION:

- Ask a student volunteer to demonstrate the method of massing each one of the objects using the proper technique. If no one volunteers, choose a student and guide him/her through the procedure or ask the students to explain how they would mass each object, and then demonstrate the proper technique.

PROBLEM: Here are three plastic bags. Each bag has something in it. Bag #1 contains a block of wood (or an appropriate substitute); Bag #2 is half filled with water colored with food coloring; and Bag #3 is filled with air. How will we mass each object?

NOTE: Mass an empty bag first. Then place the objects into each bag. Use a straw to fill the bag with air. A balloon can be substituted for the bag with air.

AIM: What is matter?

DEVELOPMENTAL STRATEGIES:

- Ask students to describe the shapes of the three objects inside the plastic bags. Establish that the wood block has a definite shape, the liquid takes the shape of the bottom of its container, and the air takes up the entire container.

- Mass the three bags separately and record the mass of each.

- Lead students to conclude that the wood block, water, and air take up space and have mass. Anything that has mass and occupies space is called matter.

- Indicate that the wood block is solid, the water is liquid, and the air is gaseous. Establish that the three phases of matter are: solid, liquid, and gas. Ask the students to name some solids, liquids, and gases found in or around the school.

- Explain that all matter is made up of tiny particles which are in constant motion. A solid has a definite shape because there are strong attractive forces between the particles holding them in definite positions, allowing only vibratory motion around these positions. A liquid takes the shape of the portion of the container that it fills. Its particles are further apart than in a solid, and as a result, the forces between them are not strong enough to hold them in definite positions. A gas fills the entire container, regardless of how large it is, because its particles are so far apart that there are essentially no forces between them to prevent them from moving even further apart. The speed with which the particles in solids, liquids, and gases move increases as the temperature increases. At the same temperature, the average speed (kinetic energy) of the particles in a solid, a liquid, and a gas is the same.

- Distribute duplicated copies of the Student Worksheet. Have students complete the activity sheet by themselves or with your help.

SUMMARY:

- Matter can be defined as anything that has mass and occupies space.

- The phases of matter are solid, liquid, and gas.

- The phases of matter depend on the distance between the molecules.

- All matter is composed of particles.

HOMEWORK:

- Define matter.

- List the three phases of matter.

- List five liquids, five solids, and two gases found in your home.

- Explain how solids, liquids, and gases are different from each other.

ENRICHMENT:

- How does temperature affect the phases of matter?

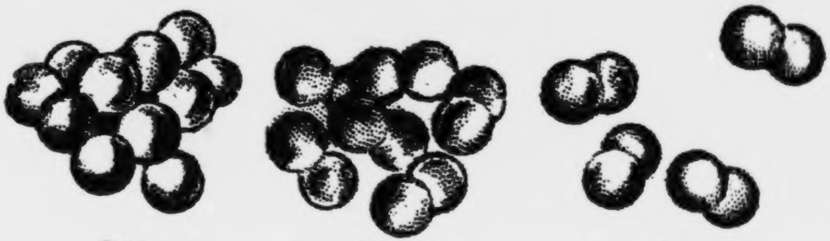
- What were some of the first attempts to describe and classify matter?

- Discuss some of the scientific contributions made by Democritus and Aristotle.

UNIT I **STUDENT WORKSHEET 1**
Lesson 1

NAME: ________________________ CLASS: __________ DATE: ________________

Spacing of diatomic molecules of iodine.



Use checkmarks to complete the following chart:

FORMS OF MATTER			
Property	Solid	Liquid	Gas
Takes up space			
Takes shape of container			
Fills container			

List five examples of each of the three phases of matter:

SOLID	LIQUID	GAS

UNIT I

LESSON 2

TOPIC: The building blocks of matter

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: H1

PROCESS SKILLS: 1, 2, 12, 17

AIM: What are the building blocks of matter?

MATERIALS:

- paper
- evaporating dish
- carbon
- test tube
- test tube holder
- aluminum
- iron
- sulfur
- copper
- zinc
- lead
- magnesium
- Periodic Table of the Elements
- Hoffman apparatus (optional)

PERFORMANCE OBJECTIVES: Students will be able to:

- explain that matter is composed of building blocks called elements.
- define elements as substances that cannot be separated into simpler substances by ordinary chemical means.
- classify most elements as metals or nonmetals.

MOTIVATION:

- Show the class a large piece of paper and then rip it in half. Ask if we still have paper. Rip the remaining paper in half and again ask if we still have paper. Continue to rip the paper until it is too small to divide.

or

- Prior to the entrance of the class, start the Hoffman apparatus for the electrolysis of water as follows:
  - Fill the tube with a solution containing one part sulfuric acid to twenty parts water by volume and apply 9-12 volts direct current from a power supply or from at least four (No. 6) 1 1/2-volt dry cells in series.

- Direct students' attention to the Hoffman apparatus. Explain that the tubes are filled with water and that this apparatus will help us find out which simple substances make up water. Demonstrate that electricity must be used to break up the water. Explain briefly that pure water conducts electricity poorly and that sulfuric acid has been added to make the water conduct electricity.

- Elicit the observation that bubbles of gas form in the tubes and rise to the tops of the tubes. Guide students to note that one tube has twice as much gas as the other.

- Recall from the previous lesson that tests can be used to find the properties of matter. Demonstrate as follows:

  - Tap off the gas of greater volume into a small test tube and hold a burning splint near the mouth of the test tube. Have the students observe the "pop" or burning that occurs. Identify the gas as hydrogen and write the word and symbol, H, on the chalkboard.

  - Tap off the other gas and test it with a glowing splint. Elicit the observation that the splint bursts into flames. Identify the gas as oxygen and write the word and symbol, O, on the board.

- Lead the class to conclude that water is made of hydrogen and oxygen. Explain that these are simple substances called elements which cannot be broken down into anything simpler by ordinary chemical means. Establish that elements are the building blocks of matter.

PROBLEM: What substances make up paper?

AIM: What are the building blocks of matter?

DEVELOPMENTAL STRATEGIES:

- Elicit that paper is an example of matter. Then place a large piece of paper into an evaporating dish and heat the paper until it becomes black, but does not burst into flames. Ask students to describe what happened to the paper. Answers should include the facts that smoke, or a gas, was given off and that some ash or powder remains in the evaporating dish. Students may think that the ash or powder in the dish is carbon. (The ash is not carbon. It consists of minerals, e.g., barium salts, used to manufacture the paper. The carbon combined chemically with oxygen during burning, forming carbon dioxide and carbon monoxide, which entered the atmosphere. Some minute carbon particles may also have entered the atmosphere as components of soot.) Locate the element carbon on the Periodic Table of the Elements. Ask the students how they can determine what was in the smoke (smoke consists of solid particles, e.g., carbon particles and various salts) given off from the burning paper.

- Elicit that smoke is an example of a gas or gases. Burn another piece of paper and allow the escaping gases to touch the chalkboard or a cold test tube. Elicit that water formed on the chalkboard or test tube. Water vapor was being given off by the burning paper. Ask the students if they know the building blocks of water. Elicit that hydrogen and oxygen are the building blocks of water (H_2O). The students should deduce that paper is composed of carbon (C), hydrogen (H), and oxygen (O). The building blocks of matter, such as C, O, and H, are called elements.

- Explain that matter can be divided into elements, but elements cannot be separated into simpler substances by ordinary means. Example: a piece of iron, an element, can be made smaller, but the smallest amount of iron is still the element iron.

- Show the class specimens of various elements--aluminum, iron, sulfur, copper, zinc, lead, and magnesium--and locate them on the Periodic Table of the Elements. Identify the elements as examples of metals or nonmetals. Show how the Periodic Table divides elements into metals and nonmetals.

SUMMARY:

- Matter is composed of building blocks called elements.

- Elements are substances that cannot be separated into simpler substances by ordinary means.

- Some elements are metals.

- Some elements are nonmetals.

HOMEWORK:

  - Explain the term "building blocks of matter."

  - Name three elements in paper.

  - Name the two elements in water.

  - List five metals and two nonmetals.

ENRICHMENT:

- Place a teaspoon of sugar into a small saucepan and heat it over a low flame on the stove. When the sugar starts to change color, hold a cool plate above the pan. Turn off the flame. From your observations, answer the following questions:

  - The color of the sugar at the beginning is __________.

  - The color of the solid substance remaining at the end is ___________.

  - When I held the plate over the pan, I saw _________ form on the plate.

  - The substance which remained is known as carbon. This substance is in the _________ phase.

- The sugar is changed to _________ and _________.

- __________ is used to break up sugar.

- This reaction can be written as: sugar → _________ and __________

- Water is made up of the elements ________ and __________.

- The elements in sugar are ________, _________, and ___________.

LESSON 3

TOPIC: The properties of elements

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: G22

PROCESS SKILLS: 1, 2, 4, 5, 6, 9, 11, 12, 14, 17

AIM: How can we tell the difference between metals and nonmetals?

MATERIALS:

- 8-cm strips of iron, tin, lead, zinc, copper, and aluminum
- sandpaper
- alcohol burner
- 2 dry cells
- set of wires
- switch
- light bulb
- clips
- lump of sulfur
- optional for laboratory: 1 of each of the above for each lab group

PERFORMANCE OBJECTIVES: Students will be able to:

- explain the differences between metals and nonmetals.
- analyze an unknown substance for metallic properties.
- design an experiment to test the metallic properties of an element.
- analyze data.

MOTIVATION:

- Show students the materials from the previous day (carbon, iron, etc.). Ask them how these materials can be categorized.

PROBLEM: What is the difference between a metal and a nonmetal?

AIM: How can we tell the difference between metals and nonmetals?

DEVELOPMENTAL STRATEGIES:

NOTE: This lesson can be either a demonstration or a laboratory exercise. Instructions are written for the demonstration. (If done as a laboratory exercise distribute materials at this point.)

- Display strips of copper, aluminum, soft iron, zinc, and lead. Ask, "In what ways are these items alike?" Lead the students to conclude that these are metals.

- Inform students that they are going to investigate some of the properties of metals and construct a data table where they will list all observations of these substances. The data table should look similar to the following:

TABLE OF OBSERVATIONS					
Properties					
Name of Metal	Phase	Luster	Color	Conducts Heat	Conducts Electricity

- Use one material at a time, and have students come up to the front of the room to record their observations. Note that the luster is the shine of the element.

  - Write the name of each metal in the first column of the Table of Observations.

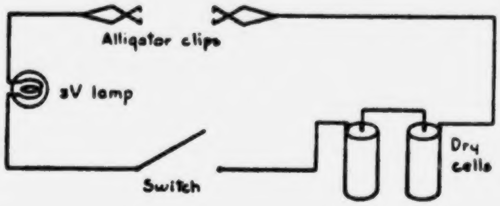
  - In the second column, state whether the metal is a solid, a liquid, or a gas.

  - Find out if each metal has a dull or a shiny surface (luster). In case of doubt, sandpaper the strips. Record your observations under "Luster."

  - Record the color of each metal under "Color."

  - Light the alcohol lamp. Hold one end of each metal strip and insert the other end into the flame. CAUTION: Remove the metal strip from the flame as soon as you feel the heat and place the strip on the ceramic pad. Record whether the metal strip conducts heat under "Conducts Heat."

- Insert the metal strips between the alligator clips of the electrical conductivity apparatus and close the switch. Record your observation in the final column.



- Display a sample of sulfur and have students observe and describe its properties (yellow, solid, odorless).

- Test the sulfur for electrical conductivity.

- Introduce the terms malleability (ability to be hammered into shapes) and ductility (ability to be drawn into a wire). Elicit that these are properties of metals. Demonstrate malleability by hammering a corner of the lead strip.

- Use one of the metals as an unknown. Have the students work through the data table and determine if the substance is a metal or a nonmetal.

NOTE: If done as a laboratory exercise you should spend adequate time going over the classroom rules for a laboratory period. Include laboratory safety, formation of lab groups, how to obtain equipment, and clean-up techniques. Distribute Student Worksheet. The conductivity apparatus should be set up for each group in advance.

SUMMARY:

- Metals have luster, conduct heat and electricity, and are malleable and ductile.

- Most elements are metals.

HOMEWORK:

- Name three properties of metals.
- Name five objects made of metal found in your home.
- Name the main metallic element in each object you listed.
- Name the only metal that is not a solid at room temperature.

- Why are electrical wires always made of metal?

- Why must the iron used to remove the wrinkles from clothing be made of metal?

- Name three properties of nonmetals.

- What are three uses for nonmetals?

ENRICHMENT:

- Examine metallic objects in your kitchen. Make a list of ten metallic objects, and specify the elements of which they are composed. What property or properties of those elements make them useful for their particular jobs?

- Examine nonmetallic objects in your kitchen. What properties of these objects make them useful for their jobs?

36

TABLE OF OBSERVATIONS

	Properties				
Name of Metal	Phase	Luster	Color	Conducts Heat	Conducts Electricity
copper					
aluminum					
iron					
tin					
lead					
zinc					

LESSON 4

TOPIC: Elements combine with each other

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: H1, H11, H20

PROCESS SKILLS: 1, 2, 9, 10, 11, 12, 14, 17, 20

AIM: What happens when elements combine?

MATERIALS:

- magnesium ribbon
- bunsen burner or alcohol burner
- tongs
- iron filings/powder
- sulfur
- magnet
- mortar and pestle
- test tube and test tube holder
- water
- paper towels
- Periodic Table of the Elements

PERFORMANCE OBJECTIVES: Students will be able to:

- form a hypothesis based on the results of an experiment.
- demonstrate that elements combine to form new substances having properties that differ from those of the original elements.
- identify substances made of a chemical combination of two or more elements as compounds.
- deduce that compounds are usually formed by combining a metal with a nonmetal.

MOTIVATION:

- Have students examine a piece of magnesium ribbon. Elicit some of the properties of the magnesium ribbon and write them on the chalkboard. (The list of properties should include: gray or silver color, luster, malleability, etc.) Ask students what will happen when the magnesium ribbon is placed in a bunsen burner flame. **CAUTION: Warn students not to look directly at the burning magnesium.**

PROBLEM: When the magnesium ribbon burned it became a white powder. Ask students if they can explain what happened to the magnesium ribbon.

AIM: What happens when elements combine?

DEVELOPMENTAL STRATEGIES:

- Refer to the motivation and elicit or explain the changes in properties that occurred when the magnesium ribbon burned. (Magnesium combined with oxygen to form a new substance whose properties are different from those of the original piece of magnesium.) Use the Periodic Table of the Elements to locate magnesium, Mg (a metal) and oxygen, O (a nonmetal). Write the word equation for the reaction on the chalkboard: magnesium + oxygen → magnesium oxide.

- Thoroughly mix a small portion of iron filings with an excess amount of sulfur. Call on students to separate the iron filings from the sulfur with a magnet. Guide students to conclude that mixing iron and sulfur together does not result in any changes in the properties of the elements.

- Fill one quarter of a small Pyrex test tube with the iron-sulfur mixture. Hold the test tube with a test tube holder and heat the mixture gently and evenly. When the contents glow, remove the tube from the heat. Call attention to the glow as an indication that a chemical action is taking place. **CAUTION: Wear safety glasses.**

- Immerse the hot test tube in a beaker of cold water to crack the test tube. If it does not crack, wrap the test tube in a paper towel and break it with a hammer. Elicit a description of the appearance of the new substance. Invite students to test the substance with a magnet to determine its magnetic properties. Elicit why the iron filings are no longer magnetic.

- Compare this set of properties to the properties of the original elements. Guide the class to conclude that a new substance with new properties has been formed. Define compound as a substance that consists of two or more elements chemically combined in a definite proportion by mass.

- Write the word equation for the reaction on the board: iron + sulfur → iron II sulfide.

SUMMARY:

- Elements can combine to form new substances having properties that differ from those of the original elements.

- Substances made of a combination of elements are called compounds. A metal and nonmetal usually combine to form a compound.

HOMEWORK:

- Classify the following elements as metals or nonmetals: sodium, chlorine, aluminum, gold, silver, fluorine, nitrogen, mercury, carbon, iodine, calcium, bromine.

- Which combinations of elements include a metal and a nonmetal: aluminum and oxygen, iron and gold, silver and sulfur, lead and bromine, nitrogen and chlorine?

- Which combinations of elements will probably form a new compound: aluminum and sulfur, calcium and oxygen, iron and aluminum, iodine and chlorine, silver and iodine?

- What kinds of elements usually form a compound?

- Elements chemically combine to form a ______________________________.

- The properties of compounds are (different from, the same as) the properties of the original elements.

ENRICHMENT:

- What are chemical symbols?

- Why are chemical symbols used in writing compounds?

- What are the rules for writing all chemical symbols?

- Who devised the modern Periodic Table of the Elements? What kinds of information did he have?

- What is a chemical formula?

- Read the labels on some household products (e.g., cake mixes, vitamin bottle, cereal packages). Find at least five compounds that are listed and determine what elements are present.

LESSON 5

TOPIC: Properties of mixtures

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: H20, H21, H22

PROCESS SKILLS: 1, 2, 3, 6, 9, 11, 12, 14, 17

AIM: How do mixtures differ from compounds?

MATERIALS:

- 400mL beaker
- 250mL beaker
- water
- evaporating dish
- alcohol lamp
- sugar
- concentrated (5M) H_2SO_4
- ceramic square
- glass stirring rod
- beaker tongs

PERFORMANCE OBJECTIVES: Students will be able to:

- define the term mixture.
- determine the differences between a mixture and a compound.
- demonstrate that the formation of a mixture involves a physical change and the formation of a compound involves a chemical change.
- give examples of mixtures.
- summarize the properties of a mixture.

MOTIVATION:

- Recall from the previous lesson that stirring the iron filings with the sulfur did not change the properties of either element. When the mixture was heated, however, the iron combined with sulfur. Elicit that a specific amount of sulfur combined with a specific amount of iron. This demonstration may be repeated for review and/or emphasis.

PROBLEM: How can we determine if a combination of substances is a mixture or a compound?

AIM: How do mixtures differ from compounds?

DEVELOPMENTAL STRATEGIES:

- Demonstrate a physical change by adding some sugar to a 250-mL beaker of water. Ask a student volunteer to suggest a way to make the sugar dissolve. (By stirring the mixture.) Elicit that the sugar dissolves.

- Place a small amount of the solution in an evaporating dish and evaporate the water over an alcohol lamp. Show students the sugar crystals remaining in the evaporating dish. Elicit that mixing sugar in water does not change the properties of either the sugar or water. Define the term mixture as a physical combination of substances--elements, compounds, or compounds and elements--each of which retains its own properties. Lead students to conclude that the formation of a mixture involves a physical change.

- To demonstrate a chemical change, place 10 grams of sugar in a 400-mL beaker. Place the beaker on a ceramic square. Slowly add between 15 and 20 mL concentrated (5M) sulfuric acid. Stir with a glass rod until a viscous mass results. Draw the attention of the class to the char and the steam. Guide students to realize that a chemical change has taken place and new substances have been formed. Lead to the conclusion that the formation of a different substance involves a chemical change. **CAUTION: Exercise extreme care in using concentrated sulfuric acid (see Safety Manual). Do demonstration in a well ventilated room. Do not hold the beaker in your hand (the reaction is exothermic). Do not handle the jar since some sulfuric acid may be left uncombined and burn the skin.**

- From this demonstration lead students to conclude that in a mixture, the parts may be mixed in any amounts. In a compound, the parts can only combine in definite proportions.

SUMMARY:

- A mixture consists of two or more substances each of which retains its own properties.

- The formation of a mixture involves a physical change. The formation of a compound involves a chemical change.

- Mixtures can be separated by physical means. Compounds can only be separated by chemical means.

HOMEWORK:

- List five mixtures that are commonly found in the home and explain why each is a mixture.

ENRICHMENT:

- List at least three methods for separating the parts of a mixture.

UNIT II

LESSON A1

TOPIC: The nature of minerals

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D12

PROCESS SKILLS: 1, 2, 14, 15

AIM: What materials make up the earth's crust?

MATERIALS:

- samples of minerals including:
  - sulfur
  - feldspar
  - quartz
  - mica
  - hematite
  - galena
- samples of rocks including:
  - granite
  - mica
  - schist
  - gneiss
  - quartzite
- photographs of earth taken from space
- the Periodic Table of the Elements
- Reference Sheet

PERFORMANCE OBJECTIVES: Students will be able to:

- define the term crust.
- describe the properties of materials that make up the crust.
- define the term mineral.
- list the eight most abundant elements in the earth's crust.

MOTIVATION:

- Demonstrate, using the Periodic Table of the Elements, that there are over ninety elements found on earth. Ask the students to describe the different features of the earth that are visible from the vantage point of space. A photograph of earth taken from space shows the blue of the oceans, white clouds, and the browns of land areas. Ask students if all the elements listed on the Periodic Table are equally represented on earth.

PROBLEM: What elements make up most of the earth's crust and in what materials are these elements found?

AIM: What materials make up the earth's crust?

DEVELOPMENTAL STRATEGIES:

- Have students examine a variety of rocks from the earth's crust. A diagram could be drawn to show the crust to be the uppermost solid layer of the earth. Elicit that these materials have certain properties. These properties include: color, phase (solid), density, chemical composition, and inorganic (not containing hydrocarbons) composition. All rock materials contain one or more substances called minerals.

- Have students examine different samples of minerals. Elicit that minerals have the following characteristics: naturally occurring, inorganic, specific chemical composition, specific physical properties, crystalline shape (orderly arrangement of atoms, molecules, or ions).

- Distribute copies of the Reference Sheet, "Eight Most Abundant Elements in the Earth's Crust." Show a sample of quartz (silicon dioxide), feldspar (aluminum, potassium, silicate), sulfur, and galena (lead sulfide). Elicit which of these minerals are the most common. (Feldspar and quartz are the two most common minerals on the surface of the earth.) Have students deduce that the earth's crust is composed of rocks and minerals. Some minerals contain only one element, e.g., sulfur, gold, silver, platinum. Most minerals contain more than one element and are compounds.

SUMMARY:

- The earth's crust is composed of rock and minerals.

- A mineral is a single solid element or compound occurring naturally in the earth's crust.

- Minerals make up rocks.

- There are only eight common rock-forming elements.

HOMEWORK:

- Which element is the most abundant in the earth's crust?

- Which element is the second most abundant in the earth's crust?

- Which of the eight most abundant elements are metals? Nonmetals?

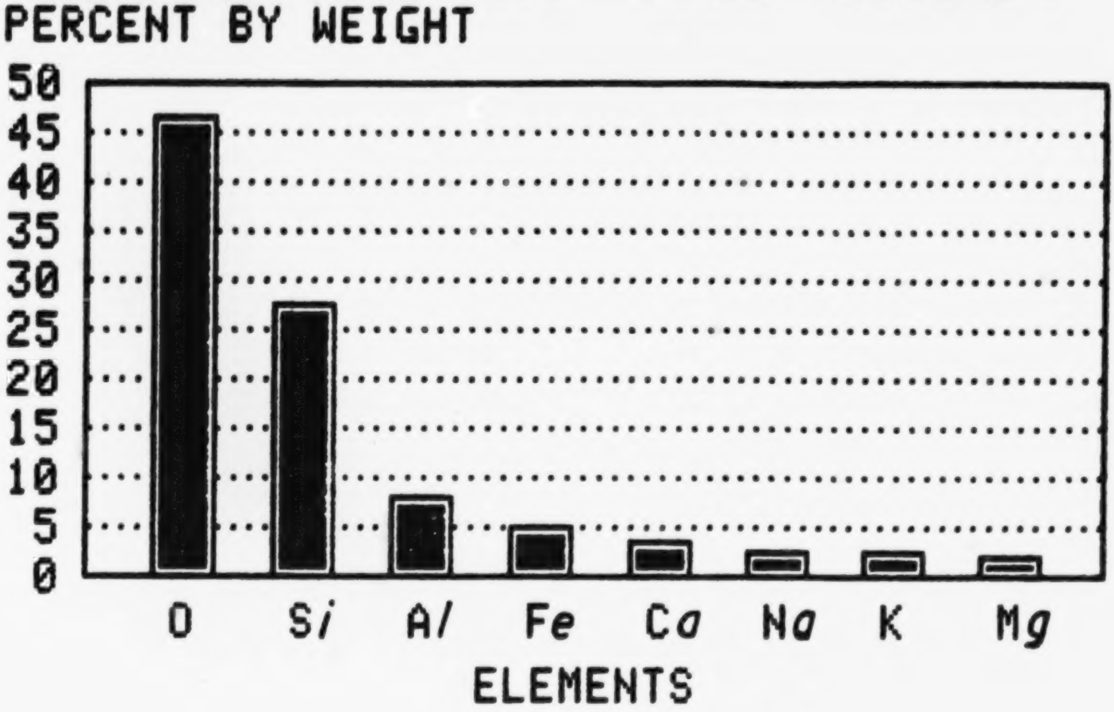
ENRICHMENT:

- Compare the composition of the crust of the earth with that of the moon.

- Report on the composition of other planets.

- Draw and label a diagram showing the internal structure of the earth.

EIGHT MOST ABUNDANT ELEMENTS IN THE CRUST



LESSON A2

TOPIC: The major groups of minerals

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D

PROCESS SKILLS: 1, 13, 14, 17

AIM: What are the major groups of minerals?

MATERIALS:

- samples of minerals from the following chemical families:
  - silicates (quartz, feldspar)
  - sulfides (galena, pyrite)
  - oxides (hematite, magnetite)
  - carbonates (calcite)
  - halides (halite)
- the Periodic Table of the Elements

PERFORMANCE OBJECTIVES: Students will be able to:

- explain that most minerals exist as compounds.
- identify the most common family of minerals as the silicate family.
- identify carbonates, sulfides, oxides, and halides as other important families of minerals.

MOTIVATION:

- Review the chart from the previous lesson representing the eight most abundant elements found in the earth's crust. Review which of the elements are metals and which are nonmetals. Explain that metallic elements combine with nonmetallic elements to form minerals. Ask students if it is possible to predict which minerals could be formed by the combination of the eight elements most abundant in the earth's crust.

PROBLEM: Which elements combine to form the most common minerals found in the earth's crust?

AIM: What are the major groups of minerals?

DEVELOPMENTAL STRATEGIES:

- Elicit that the two most abundant elements found on earth are oxygen and silicon. These elements form the basis of the silicate family of minerals, which consists of all minerals made up of silicon, oxygen, and (usually) a metal. The silicates are the most common group of minerals. Examples include quartz and feldspar.

- Using the Periodic Table of the Elements, explain that some metals combine with oxygen to form the oxide group of minerals. Examples include hematite and magnetite.

- Some metals combine with sulfur to form the sulfide group of minerals. Examples include galena (lead sulfide) and pyrite (iron sulfide).

- Some metals combine with carbon and oxygen to form the carbonate group. Examples include calcite (calcium carbonate) and malachite (copper carbonate).

- Some metals combine with the halogen family (F, Cl, Br, I) to form the halide group. Examples include halite (sodium chloride) and fluorite (calcium fluoride).

- Tell students they will classify the following minerals according to their chemical groups or families:

  galena, PbS
  hematite, Fe_2O_3
  cuprite, Cu_2O
  zircon, $ZnSiO_9$
  spinel, $MgAl_2O_4$
  corundum, Al_2O_3
  calcite, $CaCO_3$
  kyanite, $Al_2Si_3O_8$
  feldspar, $KAlSi_3O_8$
  dolomite, $CaMg(CO_3)_3$

- Write the following heading of mineral groups on the chalkboard: Silicates, Oxides, Sulfides, Carbonates, Halides.

- Have students copy the headings off the board and complete charts at their desks. When concluded, ask for volunteers to fill out the chart on the board.

SUMMARY:

- The minerals of the silicate family are the most abundant of the earth's crust.

- Other major mineral families are oxides, sulfides, carbonates, and halides.

HOMEWORK:

- What are the names of the major mineral families?

- How are the most abundant elements in the earth's crust related to the major mineral families?

ENRICHMENT:

- Report on the value of a particular mineral family.

- Report on the Hall of Gems and Minerals at the Museum of Natural History. Discuss the method(s) used for classifying the minerals and gems on exhibit.

UNIT II

LESSON A3

TOPIC: Minerals can be identified by their properties

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D2-D10

PROCESS SKILLS: 1, 2, 4, 5, 12, 14, 15

AIM: How can we identify a mineral?

MATERIALS:

- mineral samples such as sulfur, galena, rose quartz, milky quartz, hematite, calcite, mica, halite, magnetite, feldspar
- copper penny
- glass plate
- streak plate
- magnet
- dilute hydrochloric acid
- dropping pipette
- chalk (1 piece for each student)
- safety goggles
- Student Laboratory Sheets
- pictures of diamonds of various colors

PERFORMANCE OBJECTIVES: Students will be able to:

- explain what is meant by the term physical property.
- describe the most useful physical properties for mineral identification.
- demonstrate how to make observations using simple physical and chemical tests.
- categorize data in an organized matter.
- compare and contrast the properties of several different minerals.

MOTIVATION: (Use one or more of the following for the motivation.)

- Show the class a sample of iron pyrite. Tell them that many gold prospectors were fooled by this substance, called Fool's Gold. Ask students if they would have made the same mistake. Elicit why they were fooled.

- Show samples of quartz of various colors, e.g., rose, milky, clear; amethyst, jasper. Ask the class what problem is presented by the different colors of quartz.

- Elicit the color of a diamond. Show pictures of diamonds of various colors.

- Show the class four different minerals that look alike, e.g., quartz, calcite, halite, gypsum. Ask how one can tell them apart.

PROBLEM: There are over two thousand minerals. How can we distinguish one mineral from another?

AIM: How can we identify a mineral?

DEVELOPMENTAL STRATEGIES:

- Distribute small pieces of white chalk to each student. Elicit a list of the physical properties of chalk and write it on the board. Elicit the meaning of each property or characteristic. Include color, streak (the color of the mineral's powder), hardness (the ability of a mineral to scratch or be scratched by another mineral), cleavage (breaks along smooth surfaces) or fracture (breaks unevenly), luster (how light reflects from the surface of the mineral). Luster can be classified as metallic or nonmetallic (examples of nonmetallic luster include glassy, waxy, and dull). Other physical properties include attraction to a magnet and specific gravity (the comparison of the density of a mineral to the density of water).

- Demonstrate the use of the streak plate to determine streak. Explain the Mohs Scale of Hardness. Show how the fingernail (hardness 2.5), copper penny (hardness 3.5), and a piece of glass (hardness 5.5), can help determine the hardness of a mineral. Demonstrate the acid test, using one or two drops of dilute hydrochloric acid on chalk. Caution: Use safety goggles during the acid test. The effervescence or bubbling indicates a gas is being given off and usually indicates a carbonate, such as the mineral calcite. This is an example of a chemical property of a mineral.

- Distribute mineral samples, Student Laboratory Sheets, and equipment to each laboratory group. If you have enough samples and equipment, two students per group is best. Ask students to determine the physical properties of the mineral samples. See Teacher's Laboratory Sheet.

SUMMARY:

- Minerals have specific physical properties which can be used to identify them.

- Information can be gathered about the color, streak, hardness, luster, cleavage or fracture of each mineral.

- A simple chemical test (drops of dilute HCl) can also provide information useful in the identification of a mineral.

HOMEWORK:

- Complete the Student Laboratory Sheet.

ENRICHMENT:

- Identify unknown minerals using laboratory equipment and a reference work on minerals.

- Report on precious and semiprecious gems.

STUDENT LABORATORY WORKSHEET

NAME_________________________ CLASS________ DATE___________ LAB GROUP_____

PROBLEM: How can we identify a mineral?

HYPOTHESIS: ____

____

____

PROCEDURE:

1. Prepare a chart for recording data on the physical properties of minerals.
2. Test for the properties of each mineral, and record the results on the data chart.

MATERIALS: mineral samples, copper penny, glass plate, dilute hydrochloric acid, dropping pipette, magnet, safety goggles.

DATA COLLECTION CHART:

MINERAL	Color	Streak	Hardness	Luster	Cleavage/ Fracture	Acid Test	Other
rose quartz							
calcite							
sulfur							
hematite							
magnetite							
halite							
galena							

CONCLUSION: ____

____

____

UNIT II
Lesson A3

TEACHER'S LABORATORY WORKSHEET
(page 1 of 2)

PROBLEM: How can we identify a mineral?

HYPOTHESIS: All minerals have their own specific physical and chemical properties which can be used to identify them.

PROCEDURE:

1. Prepare a chart for recording data on the physical properties of minerals.
2. Test for the properties of each mineral, and record the results on the data chart.

MATERIALS:

mineral samples, copper penny, glass plate, dilute hydrochloric acid, dropping pipette, magnet, safety goggles.

DATA COLLECTION CHART:

MINERAL	Color	Streak	Hardness	Luster	Cleavage/ Fracture	Acid Test	Other
rose quartz	pink	white	@5.5	glassy	frac.	no	non-mag.
calcite	white	white	@2.5- @3.5	non-metallic	cleav.	yes	non-mag.
sulfur	yellow	yellow-white	@2.5	non-metallic	frac.	no	non-mag.
hematite	gray blk.	reddish brown	@5.5	metallic	frac.	no	non-mag.
magnetite	blk.	blk.	@5.5	metallic	frac.	no	mag.
halite	white	white	@2.5	glassy	cleav.	no	salty
galena	silver	gray	@2.5	metallic	cleav.	no	non-mag. high sp.gr.

CONCLUSION: Each mineral has its own specific physical properties which make it possible to distinguish one mineral from another. For example, calcite, halite, quartz, and gypsum may have similar colors, and identical streaks, but may be distinguished from each other by testing for hardness, noting cleavage or fracture, and using acid test.

UNIT II

LESSON A4

TOPIC: Minerals as natural resources

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D14

PROCESS SKILLS: 14, 15

AIM: Which minerals are important to humans?

MATERIALS:

- map of the world
- Reference Sheet 1 (list of ores, stating their sources and uses)
- ore samples: galena, hematite, bauxite, chalcocite, chalcopyrite, magnetite, etc.
- Reference Sheet 2 (bar graph of the various ores of copper)

PERFORMANCE OBJECTIVES: Students will be able to:

- describe some minerals which are important to mankind.
- define the term ore.
- locate on a map the various countries where important mineral resources are found.
- explain information from a data table.
- contrast and compare data.
- analyze information from a bar graph.

MOTIVATION:

- Look around you. What materials in your classroom come from minerals? in your home? in your neighborhood?

PROBLEM: There are many different minerals found on earth. Identify the minerals which are useful to humans.

AIM: Which minerals are important to humans?

DEVELOPMENTAL STRATEGIES:

- Define ore as a rock deposit that contains minerals (usually a metal) that can be mined and/or refined.

- Show students samples of ores and ask them to describe what they see. Place the names and descriptions of each ore on the chalkboard. Distribute copies of Reference Sheet 1. Have students match the ores with the metals obtained from them. The information for this task will be obtained from the list of ores.

- Using the world map, have students locate the countries where these minerals are found. Other important ores not available as samples should be discussed and located on the map. Ask questions concerning the importance to U.S. and world economy of certain countries because of their mineral wealth. Ask questions about the use of the various metals extracted from ores.

- Elicit how minerals, because of their strategic importance and/or scarcity, could be a cause of political conflict.

SUMMARY:

- An ore is a rock deposit that contains minerals that can be mined and/or refined.

- No one country has all of the natural resources that it needs to maintain its industry and economy.

- Some parts of the world have concentrations of more than one important ore.

HOMEWORK:

- Based on the bar graphs of various ores containing copper (Reference Sheet 2), have students answer the following questions:

  - Which would be the best ore for obtaining copper? Explain your answer.
  - Which would be the worst ore for obtaining copper? Explain your answer.
  - With what nonmetal is copper usually combined? (Extra credit - find out why.)

ENRICHMENT:

- Report on a specific ore.

- Write a report or make a model describing the process by which a useful material is removed from its ore.

- Research other important ores and construct bar graphs that reflect their chemical composition.

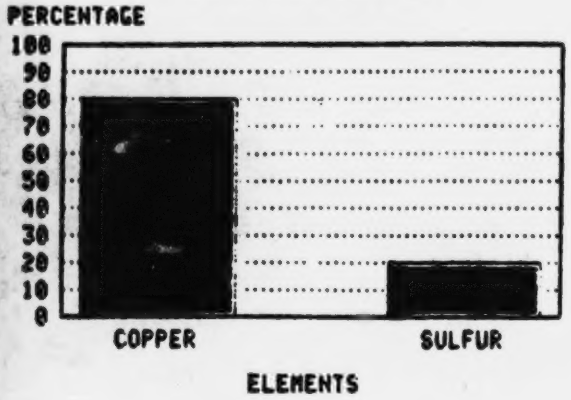
REFERENCE SHEET 1

Ore	Product or Use	Source
acanthite	silver	USSR, U.S., Mexico, Canada
bauxite	aluminum	Guinea, Australia, Brazil, Jamaica
cassiterite	tin	Indonesia, China, Thailand, Bolivia
chalcopyrite	copper	U.S., Chile, USSR, Peru, Finland
cinnabar	mercury	Spain, USSR, Yugoslavia, U.S.
galena	lead	U.S., Australia, USSR, Canada
ilmenite	titanium	Brazil, India, Canada, S. Africa
hematite	iron	USSR, Brazil, Canada, Australia
pentlandite	nickel	New Caledonia, Canada, USSR, Indonesia
spalerite	zinc	Canada, U.S., Australia, USSR
gold	gold	S. Africa, USSR, Canada, U.S.
platinum	platinum	S. Africa (82.3%), USSR, Canada
graphite	carbon for pencils and lubricants	Ceylon, Madagascar, Korea, Mexico
halite	salt, preservative, manufacture of chemicals	New York, Michigan, Texas, Louisiana, Utah, Kansas
sulfur	sulfuric acid	Texas, Louisiana, Sicily
gypsum	plaster, sheet rock, cement	New York, Michigan, Ohio, Iowa, Texas, California
apatite	fertilizer	Florida, Tennessee, North Africa, USSR
corundum	abrasives, gems	Ceylon, Burma, Thailand, China (rubies), Georgia, Carolinas, Greece, Turkey
talc	cosmetics, lubricants	England, Canada, Austria, Switzerland, Vermont, New York, Penn., R.I., N.H.

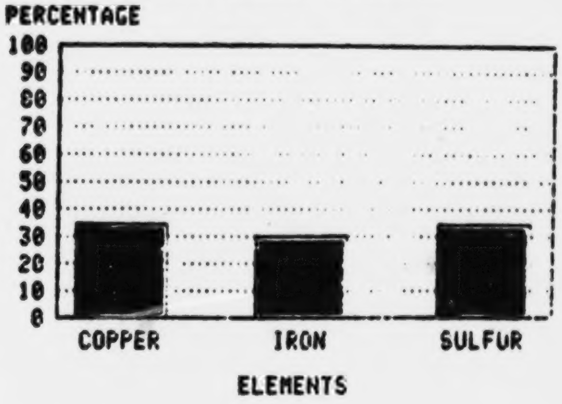
UNIT II
Lesson A4

REFERENCE SHEET 2

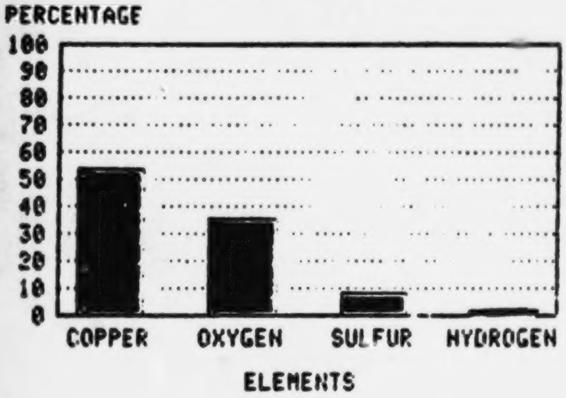
CHALCOCITE



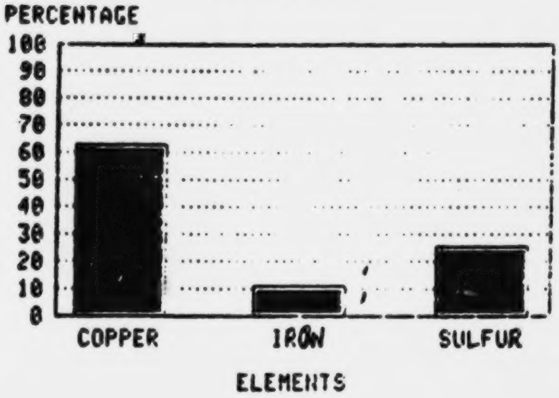
CHALCOPYRITE



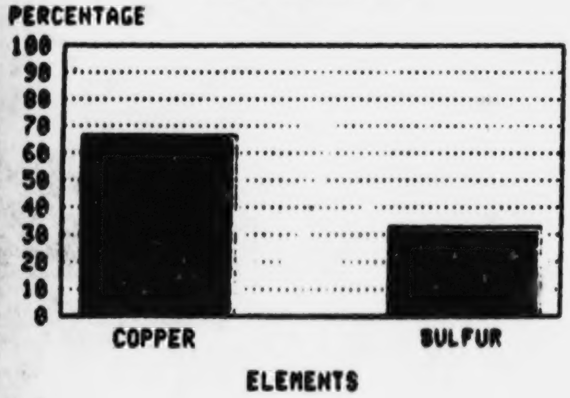
ANTLERITE



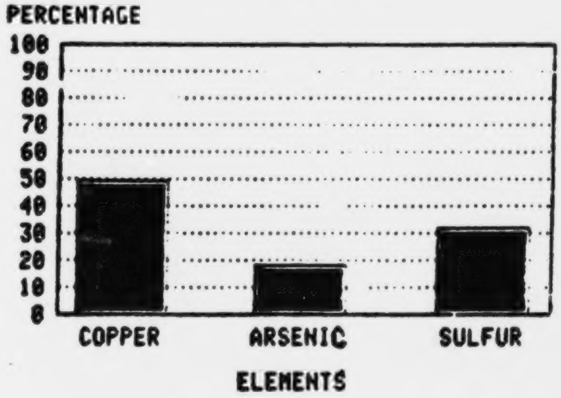
BORNITE



COVELLITE



ENARGITE



UNIT II

LESSON A5

TOPIC: The composition of the earth

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D14

PROCESS SKILLS: 1, 2, 14, 15

AIM: How can we conserve natural resources?

MATERIALS:

- photos or transparencies illustrating air pollution, water pollution, oil wells, coal mines, forests, hydroelectric power plants, windmills, nuclear power plants
- recycled paper and aluminum can

PERFORMANCE OBJECTIVES: Students will be able to:

- identify renewable and nonrenewable natural resources.
- describe various methods of conservation.

MOTIVATION:

- Shortages of oil have occurred in the recent past and may occur again. These shortages created a crisis situation.
  - Give examples of difficult problems that would occur because of a shortage of oil.
  - What could cause a future oil crisis?

PROBLEM: Many natural resources are nonrenewable. They do not replace themselves. Also, many renewable resources are being polluted or are being used faster than they can be replaced. Are there things we can do to minimize the danger of running out of important materials?

AIM: How can we conserve natural resources?

DEVELOPMENTAL STRATEGIES:

- Elicit a list of natural resources found on earth. The list should include air, water, land, minerals, fossil fuels (coal, oil, natural gas), and forests.

- Challenge students to classify the resources they just enumerated as either renewable (air, water, forests) or nonrenewable (minerals, fossil fuels).

- Elicit ideas for the preservation and conservation of natural resources, such as:

- Conservation methods including the use of less valuable resources by rationing or by finding substitute materials. Examples: ceramics replacing metals and the use of other sources of energy (wind, waves, tides, hydroelectric) to replace fossil fuels.

- Recycling (use over again). Examples: paper, glass, aluminum, plastic.

- Pollution control - attempt to keep our renewable resources of air and water uncontaminated. Examples: sewage treatment plants, sulfur-free coal, lead-free gasoline, Federal Clean Air Act.

SUMMARY:

. Nonrenewable natural resources, such as minerals and fossil fuels, may be conserved by rationing, by the use of substitute materials, and by recycling.

. Renewable resources may be protected by pollution control.

HOMEWORK:

- Classify the following as renewable or nonrenewable materials:
  - plants
  - animals
  - minerals
  - water
  - air
  - trees
  - extinct animals
  - extinct plants
  - coal
  - oil
  - natural gas

ENRICHMENT:

- Report on a specific natural resource and discuss its use and amount of reserves.

- Why would the destruction of the world's forests be devastating?

- Make a chart listing the natural resources that are in danger of being depleted in the near future.

UNIT II

LESSON B1

TOPIC: The formation of igneous rocks

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D4

PROCESS SKILLS: 1, 2, 21

AIM: How do igneous rocks form?

MATERIALS:

- 2 beakers
- test tube holder
- alcohol burner
- powdered sulfur
- matches
- hand lens
- 2 test tubes
- spatula
- short-stemmed funnel
- filter paper
- cold water
- safety goggles
- beaker large enough to float pumice
- photos and samples of extrusive and intrusive igneous rock, such as obsidian, pumice, and basalt

PERFORMANCE OBJECTIVES: Students will be able to:

- design an experiment to find the effect of cooling rate on the grain size of igneous rock.
- explain the process by which igneous rock forms.
- explain why there is a difference in the grain size of various igneous rocks.

MOTIVATION:

- Hand students samples of igneous rock. Discuss the obvious differences between them. Ask students if there are any similarities (e.g., pumice and obsidian both have the same chemical composition). Elicit explanations for the differences.

PROBLEM: When the earth formed, we believe that it was in liquid phase. What must have happened to give us what we see today?

AIM: How do igneous rocks form?

DEVELOPMENTAL STRATEGIES:

- Define the term rock as a naturally occurring solid substance composed of one or more minerals. Mention that there are three types of rocks: igneous, sedimentary, and metamorphic.

- Lead the students to deduce the cooling process that resulted in the solidificaton of molten material.

- Assist students to design an experiment, using the equipment in the materials list, by which they can find the effect of cooling rate on grain size of an igneous rock. This can be done in the following manner:

  - Using a spatula, place about one inch of powdered sulfur in a test tube.

  - Heat it over the alcohol burner until molten.

  - Pour the contents into a piece of filter paper set in a funnel over a beaker, as in Figure 1 below.

  - Repeat the procedure, but this time pour the sulfur into a beaker of cold water (Figure 2). (Sulfur may become plastic rather than solid under certain conditions. If this occurs repeat the experiment.)

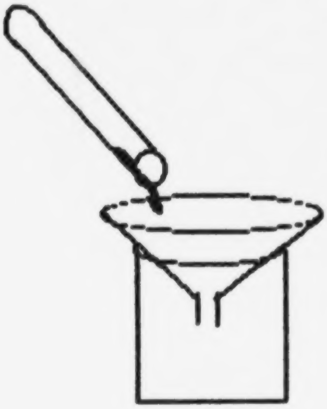


Figure 1

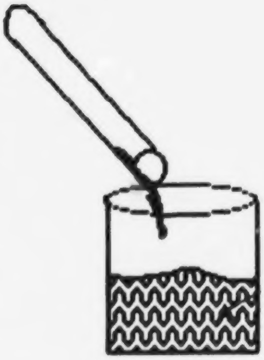


Figure 2

- When both samples have cooled, have students use the hand lens to examine the grain sizes and compare them. Caution: **Be sure that this experiment is done in a well ventilated room and that safety goggles are worn.** Warn students not to inhale the vapors.

- Using photos (or overhead transparencies), explain the difference between extrusive igneous rocks, which form from lava above the surface of the earth, and intrusive igneous rocks, which form from magma and solidify slowly beneath the surface. Note that intrusive rocks are seen only when the surface bedrock has been removed.

- Using the sample of pumice, show the class that an igneous rock can float in water. Explain that it is less dense than the water due to the many air holes left behind by the escaping gases. Have the students deduce the type of igneous rock represented by the pumice and the relative length of time it took to cool.

- Have students try to figure out which of the igneous rock samples shown are intrusive and which are extrusive.

SUMMARY:

- Rocks are mixtures of minerals.

- Igneous rocks form from solidification of molten material.

- The grain size of igneous rock is determined by the length of time it takes to cool. Rocks that cool quickly have small grains; those that cool slowly have large grains.

- The molten material originates from the crust and the upper part of the mantle.

HOMEWORK:

- Explain the difference between an intrusive rock and an extrusive rock.

- Explain why some rocks might have larger crystal sizes than others.

- Explain why some rocks might float in water.

- Explain how the properties of cooled sulfur samples differed depending on the way in which they were cooled.

- Why did the sulfur which was poured into the filter paper cool more slowly than the sulfur that was poured directly into the water?

ENRICHMENT:

- Grow crystals at home. This can be done by making a supersaturated solution of sugar or salt. To do this, mix the solute in water while heating until no more dissolves. Pour the solution into a shallow dish or glass that has a string hanging over the edge. Allow the solution to evaporate slowly. Notice that the crystals will form on the string as well as the sides of the container. A controlled experiment can be done by varying the evaporation rate in similarly set up containers.

UNIT II

LESSON B2

TOPIC: Identifying igneous rocks

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D

PROCESS SKILLS: 1, 2, 14

AIM: How can we identify igneous rocks?

MATERIALS:

Per lab group:
- box of igneous rocks containing at least 6 labeled samples, such as obsidian, pumice, and granite
- box of minerals containing labeled samples of quartz, mica, olivine, plagioclase, and orthoclase
- hand lens

For the teacher:
- large class samples of various igneous rocks, such as pumice, obsidian, granite, etc.

PERFORMANCE OBJECTIVES: Students will be able to:

- distinguish among different kinds of igneous rocks.
- describe characteristic crystal size of igneous rocks.
- identify some of the minerals present in igneous rocks.

MOTIVATION:

- Show students at least six large samples of different igneous rocks, such as pumice, obsidian, granite, pegmatite, basalt, etc., and ask them to group them by observable properties.

PROBLEM: There are many different igneous rocks. How can we distinguish one from the other?

AIM: How can we identify igneous rocks?

DEVELOPMENTAL STRATEGIES:

- Distribute materials to each lab group.

- Have students examine each specimen with the hand lens to determine the different textures of igneous rocks (coarse or smooth). Classify the rocks into as many groups as necessary according to crystal size (medium, etc.). Have students use a data table similar to the one below.

Size of Crystal

Name of rock	Coarse	Medium	Fine	None

- After classification of the rocks, have students examine them again to determine their mineral content (as in Lesson A3). Have them compare the minerals in the rocks to the mineral samples in the boxes, and then list the rocks and the names of the minerals they contain (see sample chart below).

NOTE: This will be difficult in the case of the smaller grained rocks. If you wish, you may have the students work only with the larger grained ones for this part of the lab.

Name of Rock	Minerals Present

SUMMARY:

- Igneous rocks can be identified by texture (crystal size) and mineral content.

- General categories of igneous rocks are large crystals, small crystals, and glassy (or no crystals).

- Rocks are difficult to identify for two reasons: (a) minerals do not always appear in the same amounts from specimen to specimen, and (b) minerals do not have uniform appearance from specimen to specimen.

HOMEWORK:

- Which rock had the largest crystals? The smallest?

- Which of these two rocks had cooled faster? Explain your answer.

- Name two ways of identifying igneous rocks.

- How might you determine if an igneous rock formed deep within the earth or on the surface?

- List two reasons why it is difficult to identify igneous rocks.
- Name four minerals commonly found in igneous rocks.

ENRICHMENT:

- Read and report on this, or any other book on igneous rocks you may find in your local public library: Gallob, Edward. City Rocks, City Blocks and the Moon. (New York: Scribner, 1973).
- Collect and name some local igneous rocks with the help of a rock hunter's guide from your local public library. Present the mounted collection to your teacher for review and display.

LESSON B3

TOPIC: Formation of sedimentary rocks

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D

PROCESS SKILLS: 1, 6

AIM: How do sedimentary rocks form?

MATERIALS:

Per lab group:
- paper cup
- coarse sand and fine pebbles
- Epsom salts solution
- stirring rod
- hand lens

For the teacher:
- large class samples of sandstone, conglomerate, shale, limestone
- ocean water (or 35% sea salt solution)
- small dish (such as a watch glass)
- bunsen burner or other heat source
- ringstand or other support
- large photographs (travel posters) of sedimentary landscapes

PERFORMANCE OBJECTIVES: Students will be able to:

- explain the process of formation of sedimentary rocks.
- demonstrate how sedimentary rock could be formed.

MOTIVATION:

- Display a large sample of conglomerate and ask whether or not it appears to be an igneous rock.

PROBLEM: How do sedimentary rocks, which are made of pieces of several other rocks, form?

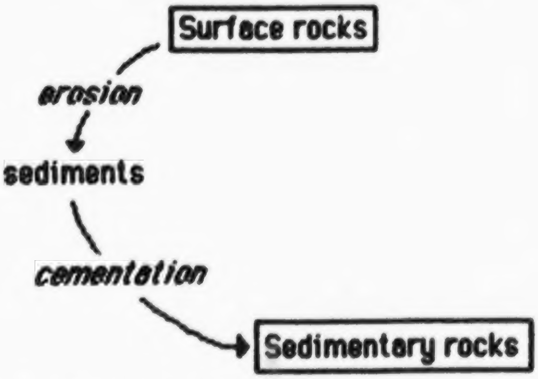
AIM: How do sedimentary rocks form?

DEVELOPMENTAL STRATEGIES:

- Discuss with students why conglomerate cannot be an igneous rock. (It displays separate rounded pieces held together by cementing material.)

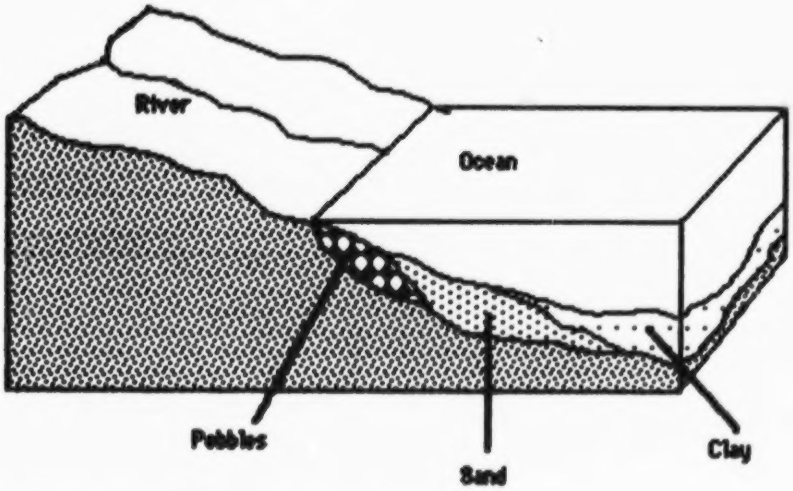
- Ask students how they think such a rock might have formed. If they are having difficulty in arriving at the concept of weathering and erosion of preexisting rocks, demonstrate the process by using a crumbly (sandstone) sedimentary rock. Have students break off a small fragment of the rock and look at the pieces under a hand lens.

- Show students the following section of the rock cycle.


Surface rocks
erosion
sediments
cementation
Sedimentary rocks

Be sure students understand that surface rocks can be of any type (igneous, sedimentary, or metamorphic); when they are broken into bits and cemented together, they become sedimentary rocks.

- Ask students to imagine what the cementing material might be. Draw the following diagram which represents a typical shoreline with sediments being deposited by a river entering an ocean.


River
Ocean
Pebbles
Sand
Clay

- Lead students to understand that the cement came from materials dissolved in the ocean water.

- Inform students that they are going to create their own sedimentary rock model. Distribute lab materials and have them devise a plan to create a "sedimentary rock." Have students pour sand and pebbles into a paper cup and add Epsom salts solution. (The Epsom salts solution should be one cup of water to about one-half cup Epsom salts. Stir until dissolved.) They will have to wait until the materials have dried (over the weekend, perhaps) and then tear away the paper cup. Have them study the model with a hand lens and make the analogy concerning the sediments and the cementing material.

- Take a sample of ocean water (or make a 35% sea salt solution) and evaporate it using a heat source. Elicit that such a process does happen (much more slowly) in nature. The resulting sedimentary rocks are called evaporites.

- Show students photographs of landscapes made of sedimentary rock layers. Desert areas usually show the layers best.

SUMMARY:

- Sedimentary rocks are formed by the cementing of sediments into a solid mass.

- Sedimentary rocks are formed from materials that have been eroded and deposited, usually in large bodies of water.

- Evaporites are formed by the evaporation of sea water.

- If we can see the layers of sedimentary rocks, it can be inferred that the water level has changed.

HOMEWORK:

- Describe how a rock can be broken up into particles which are then deposited as sediments.

- You used the Epsom salts to serve as the cement in your model of a sedimentary rock. Which substances naturally form the cementing material?

- How do conditions in nature differ from those in the laboratory?

- How do you think the temperature affects the formation of an evaporite?

- What would you know about the history of your area if you discovered that most of the rocks were layers of sedimentary material?

ENRICHMENT:

- Obtain a set of microviewer slides (National Teaching Aids) on rock types, or similar photographs of rocks taken through a microscope. Have students decide which are igneous and which are sedimentary rocks based on microscopic analysis.

- Have students who are interested in race cars read about the Western salt flats and answer the following question:

  - Why are the Western salt flats so flat and how they were formed?

UNIT II

LESSON B4

TOPIC: Identification of sedimentary rocks

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D19

PROCESS SKILLS: 1, 2, 14

AIM: How can sedimentary rocks be identified?

MATERIALS:

Per lab group:
- set of sedimentary rocks including conglomerate, sandstone, shale, limestone, fossil-containing limestone
- hand lens
- metric ruler
- dropper bottle of dilute HCl
- dropper bottle of water (optional)

For the teacher:
- large class samples of sandstone, conglomerate, shale, limestone
- 10 grams each of sand, fish tank gravel, and dirt
- 2L plastic bottle (must have clear bottom)
- samples of different sands (optional)

PERFORMANCE OBJECTIVES: Students will be able to:

- identify major types of sedimentary rocks.
- explain how the environment in which these rocks form influences the appearance of the rock.

MOTIVATION:

- Place the 10g samples of sand, fish tank gravel, and dirt in the 2L clear-bottomed plastic soda bottle. Add 1 L of water, stopper the bottle, and shake for 3 minutes. Allow the bottle to stand. Have students record their observations after 1-, 3-, and 5-minute intervals and describe the resulting characteristics of the settling contents in the bottle. Compare the results of the bottle experiment with specimens of sedimentary rock. Elicit similarities and differences.

PROBLEM: Present students with a box of sedimentary rocks. If all the rocks in the box are sedimentary, how can you explain the fact that they look different? How can we tell one from the other?

AIM: How can sedimentary rocks be identified?

DEVELOPMENTAL STRATEGIES:

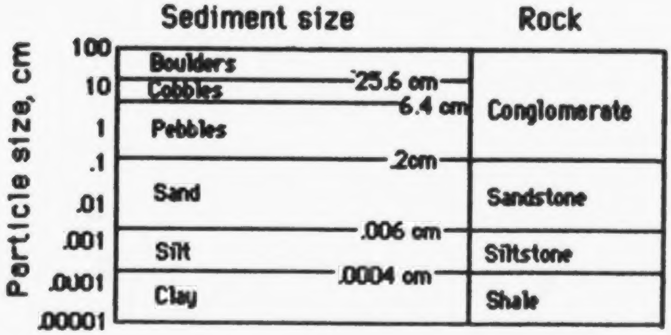
- Distribute materials to each lab group.

. Discuss with students any differences that they notice among the various samples of sedimentary rocks. This will help them set up their lab sheets for collection of data. Suggested format is as follows:

Rock	Size of particles	Shape of particles	Reaction with HCl	Other

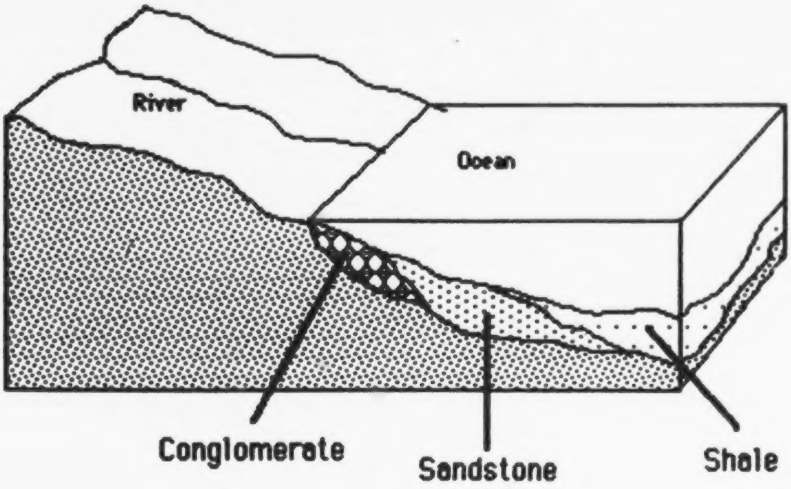
NOTE: For the conglomerate and sandstone, students should be able to measure the size of the particles. If they have trouble with the shale and the limestone, have them make a notation such as "too small to measure." They should notice the rounded nature of the sediments in the rocks. Only the limestone will react with HCl; it is actually the mineral calcite that is reacting. Students should realize that the color of the rock has no bearing on the type of rock that it is. Have them try to rub some of the particles off with their fingers. You may wish to give each group a dropper bottle of water and have them place a few drops of water on each sample. Some rocks will absorb the water, some won't.

. After the laboratory exercise, place the following chart on the chalkboard:



Be sure that the students understand that the mineral content of the sedimentary rock is not important for classification. Land-derived sedimentary rocks are classified only according to the size of the particles. It may help to show them samples of sands from different parts of the world; they may be of different colors and be made of different rock bits, but because they are all between .006 and .2 cm in diameter, they are all classified as sand.

- Refer to the previous lesson and remind students that the more rounded the particles, the further they traveled before deposition. Also, the smaller the particles, the further from shore they were probably deposited. Refer to the diagram drawn in the last lesson. Redraw it, and elicit new labels (see the drawing below).



SUMMARY:

- Sedimentary rocks may be identified by the size of their rock particles.
- They react with HCl if they contain calcite.
- The smaller and finer the rock particles in sedimentary rock, the more tightly packed they will be.

HOMEWORK:

- Can you identify rocks successfully on the basis of color? Give examples to support your answer.
- Define the term pebble. If a rock has pebbles in it, what type of rock must it be?
- Why are the pieces in a sedimentary rock rounded?
- Explain why sandstone is permeable to water while shale is not.

ENRICHMENT:

- Read about the formation of fossils. Why do you think fossils are most common in sedimentary rocks? Why are they more common in shale than in conglomerate?

. To understand how fossil footprints might form in shale, have students pour plaster of Paris into a shallow container and press a leaf or shell into it. Just before the plaster hardens, remove the leaf and a model of a "fossil" will be formed.

UNIT II

LESSON B5

TOPIC: Formation and identification of metamorphic rocks

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D20

PROCESS SKILLS: 1, 2, 14

AIM: How do metamorphic rocks form and how can they be identified?

MATERIALS:

Per lab group:
- samples of granite, sandstone, limestone, shale, slate, marble, quartzite, gneiss
- 50mL graduated cylinder with safety ring
- spring scale or triple-beam balance
- equal-size samples of one or more parent and metamorphic rocks
- string
- water

For the teacher:
- colored clay
- large samples of metamorphic rocks

PERFORMANCE OBJECTIVES: Students will be able to:

- distinguish metamorphic rocks from igneous and sedimentary rocks.
- identify some common metamorphic rocks.
- explain how metamorphic rocks might form.

MOTIVATION:

- Construct a model of igneous or sedimentary rock formations with layers of colored clay. Ask students what could happen to these "rock layers" that might result in their looking different. Students will probably suggest squeezing the clay. Do it evenly so that when they open the material, they will see "streaks."

PROBLEM: What could happen in the earth to result in a change similar to that seen in the clay?

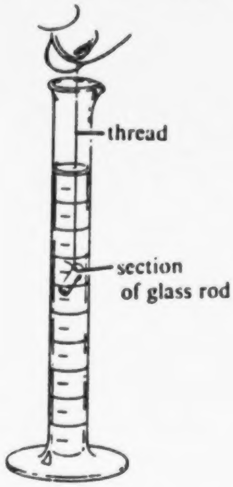
AIM: How do metamorphic rocks form and how can they be identified?

DEVELOPMENTAL STRATEGIES:

- Elicit from students that heat and pressure will cause the clay to change form--and that unimaginably great forces will do the same to rock.

- Discuss with students the processes in the earth that can provide the needed heat and pressure.

- Distribute laboratory materials. Demonstrate how to find the density of a substance using the water displacement method (see figure below). Using this method, have students follow the procedure below to determine the densities of at least one parent and one metamorphic rock of similar size.



  - Place a known amount of water into the graduated cylinder; e.g., 25 milliliters. Record the water level.

  - Tie a string around each sample. Holding the sample by the string, submerge it and record the new water level.

  - Find the volume of the sample by subtracting the known water level from the level of the water with the submerged sample.

  - Calculate density using the formula $D = m/v$.

  - Repeat the procedure for the metamorphic rock.

  - Mass the parent rock in grams.

- Record the mass in a table on the chalkboard similar to the one below:

INDIVIDUAL DATA AND CALCULATIONS		
	parent rock	metamorphic rock
mass (g)		
volume of water alone (mL)		
volume of water + rock (mL)		
volume of rock (mL)		
density of rock (g/mL)		

- Help students in the preparation of the following data table:

Parent Rock	Metamorphic Rock	Differences and Similarities Noticed
granite	gneiss	
limestone	marble	
shale	slate	
sandstone	quartzite	

- Explain to students that the rock listed under Metamorphic Rock was formed from the rock in the Parent Rock column (gneiss comes from granite, etc.). Have them study the rocks, and record any similarities or differences between the original rock and the metamarphic rock in the data table. It is important for students to conclude that metamorphic rocks tend to be more dense than their parent rocks. The minerals tend to be found in bands, and the rock itself may be foliated.

SUMMARY:

- Metamorphic rocks are formed from sedimentary, igneous, or other metamorphic rocks.

- Heat and pressure are agents that produce metamorphic rocks.

- Some examples of common metamorphic rocks are gneiss, schist, slate, and marble.

- Metamorphic rocks are usually more dense than other types of rocks because they are formed by extreme pressure.

- Banded rocks may be composed of several minerals while unbanded rocks usually contain only one. The banding is due to the pressure on the rock.

- Metamorphic rocks may be foliated due to the pressure.

HOMEWORK:

- How are metamorphic rocks formed?

- Explain why metamorphic rocks are usually more dense than other rocks.

- What property of slate makes it useful for stepping stones, chalkboards, and roofs?

- How could you prove that marble is formed from limestone?

- From what types of rocks can metamorphic rocks form?

ENRICHMENT:

- Begin a collection of local metamorphic rocks. Manhattan and the Bronx are very good collecting areas.

- Find out how different types of rocks are used locally.

- Study the rocks of your school both inside and outside the building. Are metamorphic rocks used in any of the construction? If so, which rocks and where?

LESSON B6

TOPIC: The rock cycle

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D

PROCESS SKILLS: 19, 22, 23

AIM: What is the rock cycle?

MATERIALS:

Per lab group:

- index cards with the following labels preprinted on them: igneous rocks, erosion, deposition, sediments, cementing, sedimentary rocks, melting and hardening, metamorphic rocks, heat and pressure
- pieces of yarn
- several rock samples of each type (sedimentary, igneous, and metamorphic)
- samples of sediments

PERFORMANCE OBJECTIVES: Students will be able to:

- produce a model of the rock cycle.
- place samples of rocks in the rock cycle in the appropriate places.

MOTIVATION:

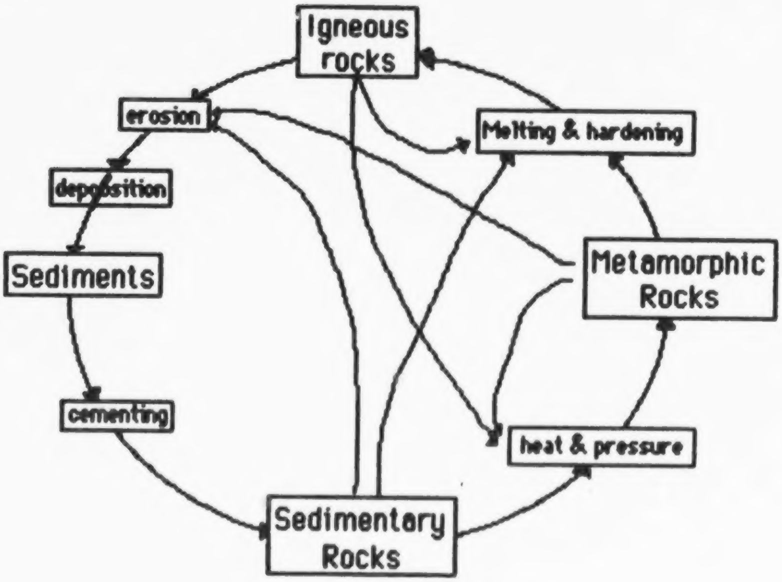
- Show students samples of igneous, sedimentary, and metamorphic rocks. Remind students that the earth formed in liquid state.
  - Why then are there other types of rocks besides igneous rocks? (Elicit how sedimentary and metamorphic rocks are created.)

PROBLEM: How can we design a model to show how rocks are related?

AIM: What is the rock cycle?

DEVELOPMENTAL STRATEGIES:

- Distribute the prelabeled cards and yarn. Explain to students that their task is to lay the cards out in such a way that they create a model of what really happens in nature. They will attempt to show that the various rock types are related. The yarn should be used to connect the cards. Help students achieve the correct rock cycle. Cycles should be like the one below:



It may seem complicated, but it is important for students to understand that any type of rock can undergo some sort of process to turn into another type of rock.

- Distribute samples of materials. Tell students that they are to place the various types of rocks and sediments on the appropriate cards so that they will have a visual guide showing what happens in the rock cycle. Check to see that both the cycle and the placement of the rocks are done correctly.

- To be sure that students understand the concept, ask: "What is necessary for the formation of metamorphic rocks?" "How could a sedimentary rock turn into an igneous rock?"

SUMMARY:

- The rock cycle is a process by which one type of rock changes into another type of rock.

- Any type of rock can change into any other type of rock, or even into a new sample of the same type of rock.

HOMEWORK:

- Explain how a sedimentary rock can become an igneous rock.

- Explain how the igneous rock granite could become the igneous rock obsidian.

- A rock was heated; it melted; then it cooled and hardened. What type of rock did it become?

- A rock originally had fossil footprints in it. Later in time, the rock was compressed and the footprint was no longer visible. What was the original type of rock and what did it become?

ENRICHMENT:

- Start a rock collection. Look up the rocks and identify them. Bring them into class to share.

- Draw a diagram showing a cut-away view of a section of the earth. Show all three types of rocks in the process of formation.

- Choose five rocks from each major category and find out how they are used commercially. What properties of each rock makes it useful for that purpose?

LESSON C1

TOPIC: Surface features of the earth

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D1, D6, D7

PROCESS SKILLS: 2, 14

AIM: What are the major landforms on the surface of the earth?

MATERIALS:

- physiographic relief map of the United States
- water-soluble marking pens
- landform map kits (one for each pair of students)
- transparency of the United States and overhead projector
- geology demonstration kit

For enrichment:
- stereophoto kit
- aerial stereogram book

PERFORMANCE OBJECTIVES: Students will be able to:

- identify and classify three major landforms.
- describe how constructional forces result in plateaus, plains, and mountains.
- distinguish one landform from another by its characteristics.
- interpret a physiographic relief map.

MOTIVATION:

- Display a relief map of the United States or place a transparency showing a relief map of the United States on the overhead projector. Point out that different parts of the map appear to have similar surface features.

PROBLEM: How can we use a map to locate major landforms?

AIM: What are the major landforms on the surface of the earth?

DEVELOPMENTAL STRATEGIES:

- Distribute one map and materials to each pair of students. Refer to the physiographic relief map of the United States. Point out the Appalachian Mountains. Ask a student volunteer to point out another area that has similar characteristics. (The student will probably point to the Rocky Mountains.) Ask the student why he/she chose that particular area. Elicit that it looked like the Appalachian Mountains. Tell the class that all the similar features on the map represent mountains and that mountains are one of the major landforms on the surface of the earth. Mountains may originate by movement of bedrock (folded mountains and fault-block mountains) or by volcanism (dome mountains and volcanic mountains).

- Demonstrate the formation of mountains (folded, fault-block, dome, and volcanic) with the geology demonstration kit or some suitable substitute. Demonstrate that the forces responsible for mountain building are constructional.

- Point out the large broad area in the center of the physiographic relief map and ask a volunteer to describe its characteristics. Elicit that the area looks flat and smooth and that it is very different from the mountains. Tell the class that this area is known as the Great Plains and illustrates another major landform, plains. Plains are associated with fairly stable regions; while constructional forces are important in the formation of plains, they act very slowly. The rock strata of plains may originate from uplifted continental shelves, river deposits (flood plains), glacial deposits, lake floors, or lava flows.

- In the western part of the United States, there is an area in between the mountain ranges. Identify it as the Colorado Plateau. Elicit that it looks like the Great Plains but it is more rugged. Tell the class that the plateau is another major landform and is an elevated plain. The plateau is a result of slow uplift folding or faulting. The elevated bedrock of a plateau may originate from faulting, from the slow uplift of bedrock without faulting, or from lava flows. Demonstrate the process to distinguish it from mountain building.

- Elicit that plains, plateaus, and mountains are the three major landforms on the surface of the earth.

SUMMARY:

- Plains, plateaus, and mountains are major landforms developed mainly by constructional forces.

- Plains are broad, flat regions of undisturbed horizontal rock strata that have little variation in elevation (low relief).

- The rock strata of plains may originate from uplifted continental shelves, river deposits (flood plains), glacial deposits, lake floors, or lava flows.

- Plateaus have undisturbed horizontal bedrock with high relief, usually more than a thousand feet.

- The elevated bedrock of a plateau may originate from faulting, the slow uplift of bedrock without faulting, or lava flows.

- Mountains have disturbed or nonhorizontal bedrock. They may originate by movements of bedrock (folded mountains and fault-block mountains) or by volcanism (dome mountains and volcanic mountains).

HOMEWORK:

- List and describe the three major landforms discussed in class.

- Describe how each is formed.

ENRICHMENT:

- Use the stereophoto kit to observe stereoscopic three-dimensional views of selected locations.

LESSON C2

TOPIC: Changes in the earth's surface

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D1, D6, D7

PROCESS SKILLS: 1, 2, 9, 14, 17

AIM: What causes the earth's surface to change?

MATERIALS:

- quartz crystals and sand
- 10X hand lens
- 35mm slides showing earth's features (such as volcanoes, earthquakes, mountains, glaciers, rivers, waves)
- overhead or film projector (VCR if available)
- transparencies showing volcanoes, earthquakes, glaciers, rivers, waves, mountains
- samples of weathered and unweathered rock
- pieces of limestone, shale, or gypsum
- large beaker
- large plastic jar with lid
- water
- large world map

PERFORMANCE OBJECTIVES: Students will be able to:

- define destructive and constructive forces.
- compare weathered and unweathered rocks or minerals.
- infer which forces wear down and which forces build up land.

MOTIVATION:

- Show samples of weathered and unweathered rock. Ask students what could cause the differences in the two rocks.

or

- Show students a world map and ask them to locate places where there are volcanoes, mountain chains, and earthquake regions. Ask students what causes the formation of these regions and what causes the same type of rocks to look different.

PROBLEM: Are the forces that made the earth look the way it does still occurring?

AIM: What causes the earth's surface to change?

DEVELOPMENTAL STRATEGIES:

- Elicit the location of the Hawaiian Islands on the world map. Ask students how these islands formed. Point out that the Hawaiian Islands were formed by constant volcanic eruptions over millions of years where the magma (the liquid rock material beneath the earth's surface) reached the earth's surface, cooled, and hardened into solid rock. This cooled lava built up, eventually protruding out of the Pacific Ocean to form an island. Show students 35mm filmstrips, 35mm slides, or transparencies (videotapes from Planet Earth: Part 1 or The Making of a Continent: Part 1, if available) to demonstrate how volcanic eruptions build up the land.

- Using the world map, ask students to identify locations on the earth where earthquakes are frequent. Point out that, although earthquakes may be destructive to humans, they tend to raise and build up the land. Forces that tend to raise and build up the land are called constructive forces. Show the students slides, filmstrips, or transparencies (or videotapes if available) showing the effects of earthquakes on the land.

- Using the world map, ask students to identify regions which include mountains and mountain chains. Ask why there aren't mountains all over the world. Ask students if they see a relationship between mountains and volcanic activity and earthquakes. Show students that mountains tend to be in areas where there are many earthquakes and volcanic eruptions. Show students how the crust of the earth moves around creating earthquakes, allowing magma to reach the surface, and causing mountains to form. Ask students if mountains can be formed by other means. (Although there are volcanic mountains, most mountains have been uplifted when crustal plates have pushed against each other as a result of plate tectonic movements.)

- Show students samples of weathered and unweathered rocks of the same type, such as granite (weathered and unweathered) and granite gneiss. Ask students to describe the differences between them. (If weathered and unweathered rock of the same type is unavailable, show students samples of any rounded, smooth rocks and sharp-edged angular rocks.) Ask students to describe the differences between them. Give students samples of quartz crystals and sand and ask them to observe both with a hand lens. Ask students if they note any differences between the quartz pieces and the sand grains. Elicit that weathered rocks or minerals are generally round and smooth and that unweathered rocks and minerals are sharp-edged and very angular. Elicit the forces that could alter the shape of these rocks and minerals (water, exposure to elements, etc.).

- As a demonstration, show students samples of unweathered limestone, shale, or gypsum. Place a few pieces into a large plastic jar and half fill the jar with water. Point out how clear the water is before the beginning of the demonstration. Have student volunteers shake the jar vigorously for two minutes each. After six to eight minutes pour some of the water into a large beaker. Ask students to note the condition of the water now. Take out samples of the shaken mineral pieces and pass them around the room. Ask students to note the changes before and after the vigorous shaking. Forces that tend to wear down and break up rocks are called destructive forces. Elicit that the substances have weathered and that only their appearance has changed.

SUMMARY:

- There are two basic kinds of forces changing the surface of the earth, constructive and destructive.
- Constructive forces tend to build up and raise the land.
- Constructive forces include movements of crustal plates, which may cause mountains to form as well as create fissures in the crust which allow volcanoes to erupt.
- Destructive forces are those which tend to wear down the land.
- Destructive forces are also called weathering and erosive forces.
- Weathering can often be identified by observing rocks and minerals that are rounded and smooth.

HOMEWORK:

- What forces build up or level the land?
- Identify some forces that tend to raise or build up the land.
- Identify some of the forces that tend to wear down or level the land.
- Identify three regions in the United States where the land is probably being raised. Give reasons for your answers.
- Identify three regions in the United States where the land is being lowered. Defend your answers.

ENRICHMENT:

- Report on regions in the United States that are dangerous to live in because of active constructive or destructive forces. Include the force or forces that are active in those regions.
- Report on one of the constructive or destructive forces (e.g., types of mountain building, types of earthquakes, types of volcanoes, types of weathering forces).
- Prepare a short report on weathered and unweathered rocks or minerals in your local area (school, homes, local land areas). Include samples along with your reports.

LESSON C3

TOPIC: Mechanical weathering

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D2, D6

PROCESS SKILLS: 4, 6, 16

AIM: How does the earth's surface weather physically?

MATERIALS:

- assorted weathered and unweathered rock samples (8 x 13 cm), preferably granite, gabbro, or some other medium-grained rock.
- quartz pebbles
- quartz sand
- jar with screw top
- porous rock (e.g., sandstone)
- glass tubing
- bunsen burner
- assorted pictures of biological weathering

PERFORMANCE OBJECTIVES: Students will be able to:

- describe the process of mechanical weathering.
- list at least three types of mechanical weathering (e.g., biological or organic; frost action; abrasion or wind erosion)
- identify the difference between weathered and unweathered rock.
- identify climates that cause rapid weathering.

MOTIVATION:

- Hold a piece of quartz in one hand and a beaker of sand in the other. Inform students that this sand came from the quartz. Ask, "How do you think this happened?"

or

- Display two rocks of equal composition (e.g., both granite) and of approximately equal size. One sample should have unweathered surfaces, i.e., angular with distinct minerals visible. The other should be well rounded and worn. Inform students that each of the two samples is the same kind of rock because the mineral composition is the same (a medium-grained rock is the best type, e.g., gabbro, granite).

PROBLEM: If both of these samples are the same type of rock, why does one have a smooth rounded surface, while the other is angular with clearly distinct crystals visible? Why do they look so different?

AIM: How does the earth's surface weather physically?

DEVELOPMENTAL STRATEGIES:

- Use several of the following activities to illustrate mechanical weathering processes:
  - Completely fill a screwcap jar with water and tighten the cover. Wrap the jar in a piece of cloth or put it into a paper bag and allow it to freeze outdoors or put it in the freezer. The freezing water will expand and break the jar. Absorbed water often breaks rock in a similar way. Discuss the cracking of water pipes, and the developing of large holes in city streets during the winter and spring. Guide students to see that freezing water can break rocks into small pieces. Introduce the term frost wedging.
  - Carefully mass a piece of dry porous rock such as sandstone or limestone. After soaking in water overnight, remass the sample. Discuss what might happen if the water were to freeze.
  - Examine the sidewalks and highways near the school and notice the spaces that have been left between the sections. Explain that this is done to prevent breakage when the sections expand.
  - Heat the end of a piece of glass tubing in a flame and plunge it quickly into cold water. (NOTE: This should be done as a teacher demonstration only.) Many rocks will fracture in a similar way when heated by the sun and suddenly cooled by rain or a rapid drop in temperature. **CAUTION: Do not heat samples of rocks, because of the danger of explosion which may result from the conversion of absorbed water into steam.**
- Elicit what effect the roots of trees have on sidewalks. Discuss the problems people have with trees growing through foundations and breaking underground pipes. Establish that the roots of plants may break up rocks also. Refer to this as biological weathering.
- Point out that earthworms, moles, woodchucks, and other burrowing animals dig holes in the ground that allow water to enter. Elicit that this water can freeze and cause ground to break. Use the term frost wedging again.
- Discuss with students the type of climate where mechanical weathering, such as frost wedging, would most likely occur.
- Inform the class that after pieces of rock are broken apart by biological processes or frost wedging, they are worn down even more by wind and water. As rocks tumble over each other in streams, on beaches, or in deserts, they become more rounded. The sharp edges wear away and the surface becomes smooth. This process is called rock abrasion and is a continuing process.

SUMMARY:

- Rocks that are near the earth's surface crumble and decay when exposed to the atmosphere. This weathering, which may be either physical or chemical, produces rock fragments on the surface of the earth. Continued weathering of the exposed rock fragments produces soil necessary to agriculture.

87

. Physical weathering is the breaking of rock without any change in its chemical composition.

. Rain water freezes in the cracks of rocks; it expands and breaks the rocks.

. Big temperature changes (unequal cooling) cause different minerals, which expand and contract at different rates, to break apart.

. Rocks are broken up by living plants and animals.

. Plant roots growing between the cracks in rocks exert pressure which can cause further cracking.

. Some plants grow on rocks and split their surfaces.

. The rate of weathering depends upon the physical and chemical properties of the rocks, the climate, and the amount of rock exposed to the elements.

. Weathering is most pronounced in regions having a moist climate with hot summers and cold winters.

HOMEWORK:

- The following are examples of weathering. Explain how they occur.

  . Some bricks come loose from a building after a cold, wet winter.
  . The sidewalk splits near a tree.

- Due to frost action, sandstone will weather faster than quartzite. Explain why. (Hint: Both rocks contain SiO_2 (silicon dioxide) but quartzite is metamorphic.)

- There are companies that must constantly clean out clogged sewer pipes even though people take special care not to clog them. What is a possible cause of the clogging of these pipes?

ENRICHMENT:

- Identify examples of mechanical weathering in your neighborhood.

- Bring in samples of weathered rock and determine which type of mechanical weathering was responsible for its present condition.

LESSON C4

TOPIC: Chemical weathering

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D/D6

PROCESS SKILLS: 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 17

AIM: What is chemical weathering?

MATERIALS:

For demonstrations:
- 2 steel wool samples - 1 new, 1 rusted (Prepare the rusted steel wool before the lesson begins.)
- unrusted nail, rusted nail
- 10cm magnesium ribbon
- bunsen or alcohol burner
- tongs
- dilute HCl solution
- club soda
- blue litmus paper
- limestone sample
- chalk (calcium carbonate)
- 500mL beaker
- water

Per lab group:
- large limestone or marble chip (4-5g)
- small limestone or marble chips
- two 250mL beakers
- two HCl solutions (50% or less)
- triple-beam balance
- Student Laboratory Sheet

PERFORMANCE OBJECTIVES: Students will be able to:

- define and explain chemical weathering.
- demonstrate how chemical weathering occurs.
- design an experiment to demonstrate the effect of surface area on the rate of chemical weathering.

MOTIVATION:

- Ask students to look out the window and observe some of the parked cars. Elicit how they can tell if some of the cars are much older than the other cars. (Some of the cars show signs of rusting.)

or

- Ask students why cars and bridges are painted. Ask students if the chemical composition of the automobiles or bridges is affected by rusting. Elicit a definition of rusting. (Slow oxidation.) Elicit what substances cause rusting. (Oxygen and moisture.)

PROBLEM: What substances found in nature can change the chemical composition of rocks and minerals?

AIM: What is chemical weathering?

DEVELOPMENTAL STRATEGIES:

- Show students a 10cm length of magnesium ribbon. Have students note the physical properties of the magnesium. Use tongs to hold the magnesium in the flame and allow it to burn. **CAUTION: Warn students not to look directly at the flame.** After the demonstration have students note the physical properties of magnesium.

- Point out that the magnesium combined with oxygen to form magnesium oxide. Magnesium oxide differs from magnesium both chemically and physically. Write the equation for the reaction on the chalkboard:

$$\text{magnesium} + \text{oxygen} \rightarrow \text{magnesium oxide}$$
$$2Mg + O_2 \rightarrow 2MgO$$

  - When some substances react rapidly with oxygen, heat and light are produced and we say that the substance is burning. Burning is rapid oxidation.

- Show students the new and the rusted steel wool. Ask students if they know what could have caused the steel wool to rust. (Iron in the steel wool combines with the oxygen in the air. The rusting process is accelerated in the presence of moisture.) Elicit that it takes a fairly long time for some materials to rust. Write the equation for the formation of rust (iron II oxide) on the chalkboard.

$$\text{iron} + \text{oxygen} \rightarrow \text{iron (II) oxide}$$
$$2\,Fe + O_2 \rightarrow 2FeO$$

  Elicit that there are at least two substances in nature that can cause chemical changes in rocks and minerals (water and oxygen).

- Pour some club soda into a beaker. Have a student volunteer test the club soda with a piece of blue litmus paper. When a color change is noted on the litmus paper, ask students if they know which substances cause blue litmus paper to turn red. (Acids.) Place a drop of dilute hydrochloric acid on another piece of blue litmus paper and have students note the resulting color change. Elicit that HCl is an acid because it caused blue litmus to turn red. Place a few drops of club soda on a piece of limestone. Have students note the bubbling reaction. Place a drop of dilute HCl on another piece of limestone and have students note that the results are similar, although more vigorous, with HCl. Tell students that carbon dioxide in the air reacts with water vapor to form carbonic acid. Write an equation for the reaction on the chalkboard.

$$\text{water} + \text{carbon dioxide} \rightarrow \text{carbonic acid}$$
$$H_2O + CO_2 \rightarrow H_2CO_3$$

- Pour 100mL of dilute HCl into a 500mL beaker. Drop a piece of chalk into the beaker. Have students note the reaction. Ask students to predict how long it will take for the chalk to dissolve and write their predictions on the chalkboard. Show students two new pieces of chalk. Break one of them into several pieces. Ask students which of the two chalk samples will react more readily with the acid. Ask them to support their predictions and record their responses on the chalkboard.

- Distribute copies of Student Laboratory Sheet and the required lab materials.

SUMMARY:

- Chemical weathering is the breaking of rock and mineral material by chemical action, which results in a change in the chemical composition of the rock and mineral.

- Oxygen combines with minerals when they are wet, forming new compounds which are less able to hold the rock together.

- If water combines with carbon dioxide, it can dissolve some minerals in rocks.

- Acids produced by nature or by humans can react with minerals in rocks and cause the rock to crumble and fall apart.

- Increasing the exposed surface area of a rock will increase the rate of chemical weathering.

HOMEWORK:

- Define chemical weathering.

- What is oxidation?

- What happens to a rock or mineral when it undergoes oxidation?

- What is hydration?

- What actions on some minerals is caused by exposure to acid?

- What is the difference between mechanical and chemical weathering?

- In addition to rock or mineral composition, what other factors might influence the rate of chemical weathering?

ENRICHMENT:

- Prepare a short report on how industries protect their products from weathering by oxygen, water, acids, and other chemicals.

- Write a report on acid rain and how it is increasing the rate of chemical weathering, thus endangering the environment.

UNIT II
Lesson C4

STUDENT LABORATORY WORKSHEET
(Page 1 of 2)

PROBLEM: How does surface area affect the rate of weathering?

HYPOTHESIS: A mineral with more exposed surface area will weather faster than an equal mass of the same mineral with less exposed surface area.

MATERIALS: triple-beam balance, two 250mL beakers, dilute HCl, large piece of marble or limestone, small marble or limestone chips.

PROCEDURE:

1. Using the triple-beam balance, mass the large piece of limestone or marble. Then mass enough small limestone or marble chips so that the combined mass of the smaller chips equals the mass of the single larger piece.

NOTE: To obtain accurate results, the masses of the reacting particles must be the same.

2. Pour 200mL of hydrochloric acid into two 250mL beakers. **CAUTION: If you acidentaly spill the acid on clothing or skin, flush the area with water immediately.**

3. Put the large piece of limestone or marble into one beaker and at the same time put the small chips of limestone or marble into the other beaker. Begin timing the reaction for both samples.

4. Determine which sample took the longest time to react.

5. Record your results in data collection table below.

DATA COLLECTION TABLE:

	Initial time	Final time
large marble/limestone chip		
small marble/limestone chips		

CONCLUSION:

1. Was your hypothesis correct? ______________________ (yes/no)

Explain (discuss)____

____

____.

2. Did you solve the problem? ______________________________ (yes/no)

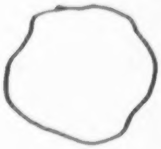
Explain (discuss) ____

____

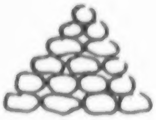
____

3. Which of the limestone samples shown below will dissolve faster if placed in acid? ________________________

Sample X



Sample Y



Sample X and sample Y represent equal masses of earth material, which are weathering under the same conditions. The samples have the same mineral composition.

4. Why will a boulder weather more rapidly as it breaks down? ______________

____

____

LESSON C5

TOPIC: Formation of caves

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D6

PROCESS SKILLS: 1, 2, 14

AIM: How are caves formed?

MATERIALS:

- dilute sulfuric acid
- limestone chips
- ring or tripod stand
- two 400mL beakers
- vise jaw clamps
- watch glass
- bunsen burner
- lamp chimney or large glass tube

PERFORMANCE OBJECTIVES: Students will be able to:

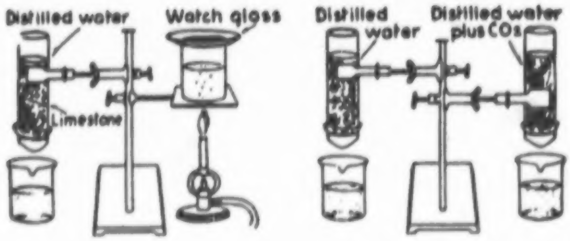
- describe the action of slightly acid water on limestone chips and apply this principle to demonstrate the effect of acid groundwater on limestone rock.
- describe how dissolved limestone may precipitate (come out of solution) to form deposits above and below the earth's surface.
- define and identify some of the results of the limestone solution and its subsequent precipitation.
- summarize the process of the destructive work of groundwater.

MOTIVATION:

- To show that acid groundwater dissolves limestone, fill a lamp chimney or large glass tube with crushed limestone or bluestone. Close the bottom of the container by tying a piece of cloth across it. Then pour slightly acid water (representing rainwater) into the container and collect it as it percolates through the chips and comes off at the bottom. Put a few drops of this water on a glass plate and allow it to evaporate. Use distilled water as a control.

or

- Prepare two chimneys of limestone as described above. Into one pour distilled water or rainwater that has been boiled to expel dissolved gases. Into the other pour unsalted seltzer water. (See diagram.) Evaporate water from each chimney and compare to the remaining sediments. There should be a large amount of sediment in the water that contained CO_2. This is good evidence that carbonic acid helps to dissolve limestone.



PROBLEM: How can we construct a model to explain how groundwater can erode limestone and apply this model to explain how caves are formed?

AIM: How are caves formed?

DEVELOPMENTAL STRATEGIES:

. Be sure students understand that the materials set up in this demonstration will help to show how slightly acidic water can wear away (dissolve) limestone.

. Inform students that although rain is chemically pure when it condenses, as it passes through the atmosphere it absorbs CO_2, oxygen, and other gases. In addition, as it percolates through the soil, it picks up other minerals and organic acids. As a result the formerly "pure" water now has the ability to react chemically with certain kinds of rock.

. Elicit that limestone is one type of rock that can dissolve in acidic water. (Refer to the demonstration.)

. Ask the class to predict what will happen over a long period of time if acidic water is allowed to come constantly in contact with limestone rock. (Elicit that over a long period of time the limestone rock will dissolve and large irregular pockets will form under the surface of the earth.)

. Refer to the motivation and ask "What will happen to the dissolved material when the water evaporates?"

. Inform students that water containing dissolved limestone drips inside these large pockets and forms long icicle-like deposits from the roof of the openings. Identify these as stalactites. Below them, growing from the floor up, are stalagmites.

. Display a transparency of a typical limestone cave and help students identify the various features.

SUMMARY:

. Groundwater, if slightly acidic, will dissolve limestone bedrock, forming caves.

. Limestone (or other material) dissolved in groundwater may precipitate and form deposits above and below the surface.

. Stalactites and stalagmites are limestone deposits often found in limestone caves.

HOMEWORK:

- What happens to rainwater as it passes through the atmosphere and soil?
- How can groundwater erode limestone?
- How are limestone deposits formed?
- List three famous caves. Where is each located?

ENRICHMENT:

- Research and report on how long it takes a cave to form.

LESSON C6

TOPIC: Erosion

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D/D6

PROCESS SKILLS: 1, 2, 9, 17

AIM: What is erosion?

MATERIALS:

- slides, filmstrips, transparencies, and/or videotapes showing landforms that have been shaped by erosive forces (Bryce or Zion canyons, for example).
- stream table with stand and source of running water (see illustration below)
- landform models (optional)
- fan or hair blower
- sand

PERFORMANCE OBJECTIVES: Students will be able to:

- define erosion.
- give examples of erosive forces.
- interpret diagrams and pictures showing erosive forces.

MOTIVATION:

- Show the class pictures of the rocky north shore and the sandy south shore of Long Island. Ask students if they know what caused these natural features.

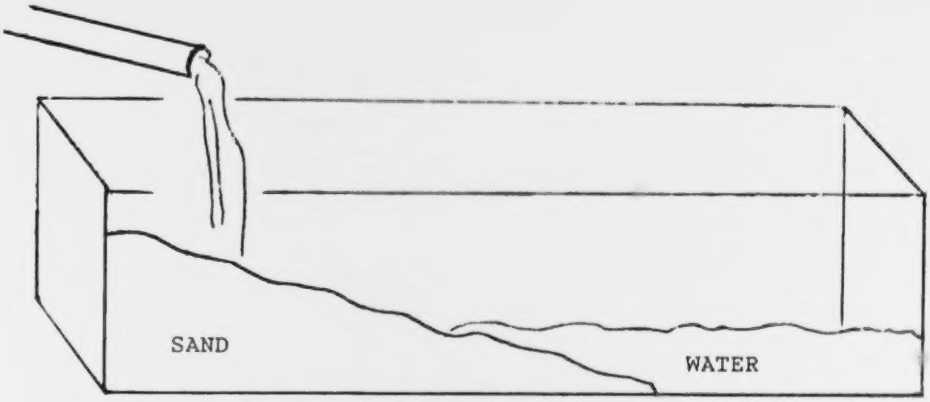
PROBLEM: How are all natural landform features formed?

AIM: What is erosion?

DEVELOPMENTAL STRATEGIES:

- Set up stream table as shown in the illustration below. If a stream table is not available then any flat, low-walled container (e.g., a wide flat plastic planter) will do, or build one in accordance with the following directions: Construct a wooden or metal trough about 1m long, 10cm high, and 20-40cm wide. Use putty or neoprene on the inside corners to make it watertight. Drill a hole for drainage in one end at the center near the bottom.

- Pour sand into the container until it is about 1/4 full. Tilt the container so that the sand forms a sloping heap at one end. (If sand is not available in school supplies, it can be obtained free at any local beach.)



PLASTIC TRAY or STREAM TABLE

- To demonstrate wind erosion, use the fan or hair blower (or simply blow) across the sand. Have students note how the sand particles move across sand layers, in turn moving other sand particles. Show photographs of Bryce Canyon or Zion Canyon and explain that they are primarily the result of wind erosion.

- Build a sand mountain in the stream table to demonstrate gravity as an erosive force. Add sand gradually to the top of the mountain. Show students that eventually gravity will start pulling sand grains down the sides of the sand mountain. As they fall, they cause more sand to fall. Gravity is an invisible erosive force.

- If you have a source of running water from a sink, use it with rubber tubing to show how running water moves particles and creates streams and stream branches which in turn remove more particles and thus wear down the land. Show students photographs of rivers and river topographies in various stages of development. Point out that the water also drips down through the sand, dissolving chemicals and weakening underlying layers, causing sinkholes and creating caverns and underground springs. Show photographs if available.

- To demonstrate glacial erosion, wet the sand all over so that both the surface and the layer just below it are moist. Use a rock or your hand to respresent how a glacier gouges out the land by scraping through the moistened sand, leaving deep valleys. Show photographs if available.

- Pour some water into the container at one end of the stream table to show a water/land interface. Use the fan or hair blower (or just blow across the water) to create waves. Have students notice how shoreline sand (the beach) is moved as a result of wave action.

- If landform models are available they can be used to demonstrate all the above erosive forces.

SUMMARY:

- Erosion is the removal or movement of surface material (which may previously have been weathered) from one location to another.

- There are many natural agents of erosion, including gravity, running water, groundwater, wind, and glaciers.
- The overall effect of these erosive agents is to wear down the land.

HOMEWORK:

- Define erosion.
- How do we know that erosive forces are at work? Give examples.
- What do the forces of erosion have in common?
- Explain how the different agents of erosion move rock material.
- Explain why eroded materials have a tendency to be deposited in the oceans.

ENRICHMENT:

- Examine your neighborhood for evidence of erosion and try to determine the agent of erosion involved.
- Examine rocks and pebbles around your home to determine if they show evidence of erosion.
- Write a report on regions in the United States or New York State that have undergone any or all of the erosive forces mentioned in class.

UNIT II

LESSON C7

TOPIC: Erosion by running water

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D6

PROCESS SKILLS: 1, 2

AIM: How does water erode the surface of the earth?

MATERIALS:

- large plastic jar with cover (e.g., mayonnaise container from the school cafeteria)
- jagged pieces of gypsum and jagged pieces of harder rock
- stream table or long trough such as a rain gutter
- sand for stream table, or gravel, sand, etc., for trough
- wire mesh
- container that will allow water to seep slowly (such as a powdered sugar strainer or large salt shaker)

PERFORMANCE OBJECTIVES: Students will be able to:

- compare water-worn material with material that is not water worn.
- list some of the agents of erosion.
- describe the action of running water on the land.
- deduce what would happen to the amount of erosion given different volumes of water and elevation of stream bed.

MOTIVATION:

- Show the class a diagram or transparency of the water cycle. Elicit that some water evaporates from the earth and then condenses and falls back. Ask students what will happen to some of this water.

PROBLEM: What effect does runoff water have on the surface of the earth?

AIM: How does water erode the earth?

DEVELOPMENTAL STRATEGIES:

- To demonstrate how rocks are worn down and broken up by running water (which causes the rocks to strike each other), place several jagged chunks of gypsum (soft rock) into a large plastic screw-top jar. Add various jagged pieces of harder rocks and pour water into the jar until it is half full. Cover the jar and give it to five energetic students to shake vigorously for 2 minutes each. Check periodically to see if the gypsum has worn down noticeably. When it has, have the class observe the change in size and shape of the rocks. They should notice a definite rounding of the rock fragments. Equate this to rounded rocks and glass found on the sea shore. Make sure students understand that water moving downhill (rivers) will cause the rocks to become smaller and more rounded.

- Elicit that rocks can also be eroded by wind, glaciers, groundwater, and wave action. However, running water is the most effective erosional agent of all.

- To demonstrate the formation of river courses and valleys, use a stream table with a very slow stream of water. If you do not have a stream table, you can use a long trough such as a rain gutter. Attach a piece of fine wire mesh to one end of the gutter, so that the sediments in the gutter will not wash out. Fill the gutter with a mixture of gravel, sand, and clay. Slightly elevate one end of the trough and start sprinkling water onto the sediments. After a while, students will begin to see the formation of a river. All of the same processes that occur over millions of years in the life of a river will be observable within minutes in the water trough.

- Using the stream table or trough, show students that by increasing the height at one end, the stream will flow faster and the rate of erosion will increase. Also, by increasing the amount of water in the stream, the rate of erosion will increase.

- Depending on the amount of time available, many other demonstrations can be done with the trough, such as showing the formation of meanders, oxbow lakes, deltas, waterfalls, etc. However, it is more important that students understand that the rate of flow and the angle of stream are the major contributors to water erosion.

SUMMARY:

- Erosion is the process of breaking up and transporting materials from one place to another.

- Running water is the most effective agent of erosion.

- Running water causes the rounding of rocks over which it moves.

- The ability of the stream to erode land is most influenced by the angle of the stream and the amount of water in that stream.

HOMEWORK:

- Draw and label a diagram of the water cycle.

- Describe which of the rock fragments in the jar was affected most by water erosion. Why?

- List two factors which will determine the rate of erosion caused by running water.

- Explain why rivers cause more erosion than other agents.

ENRICHMENT:

- Find out how rocks are polished. If you know someone with a rock tumbler, observe the process and report to the class.
- Explain how moisture from the breath of a dinosaur could fall as a snowflake today.

UNIT II

LESSON C8

TOPIC: Groundwater

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D6

PROCESS SKILLS: 1, 2, 14, 17, 11

AIM: What influences the rate of infiltration of groundwater?

MATERIALS:

Per lab group:
- 3 funnels
- 10g samples of clay, sand, and gravel
- a 500mL beaker
- three 5cm squares of cheesecloth
- string
- a 25mL graduated cylinder
- water

PERFORMANCE OBJECTIVES: Students will be able to:

- compare samples of sediments to determine the seepage rate of water.
- explain what happens to groundwater under the surface.

MOTIVATION:

- The directions for planting strawberry plants indicate that the plants should be in sandy soil. Elicit possible explanations for this.

PROBLEM: What happens to the water that seeps into the earth?

AIM: What influences the rate of infiltration of groundwater?

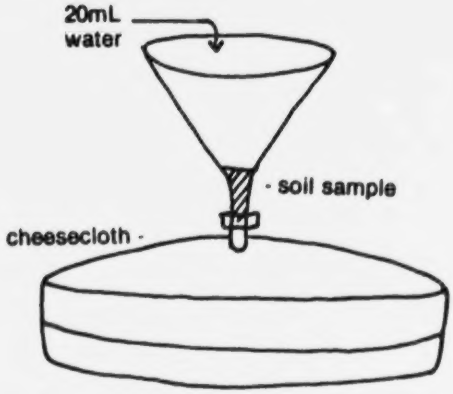
DEVELOPMENTAL STRATEGIES:

- Discuss the benefits of planting strawberries in sandy soil. (Strawberries require soil that drains well. Water tends to puddle on clay soil but seeps through sandy soil.)

- Distribute materials. Inform students that they are going to perform an experiment to determine how to test the infiltration rate of different types of soils, following the procedure below. (The infiltration rate is the seepage of precipitation into the earth. The amount of infiltration is dependent upon porosity and permeability.)

  - With string, secure cheesecloth squares to one end of each of the three funnels.
  - Place 10g of clay into one of the funnels.

- Hold the tube over a 500mL beaker and add 20mL of water.



- After 5 minutes measure the amount of water in the beaker by pouring it into a graduated cylinder. Record the measurement into a data table similar to the one below.

1 Soil sample	2 mL water before filtering	3 mL water after filtering	4 Diff. between cols. 2 and 3
Clay			
Sand			
Gravel			

- Repeat the procedure for the sand and potting soil samples.
- Make a bar graph of your results.

SUMMARY:

- Some precipitation may seep into the ground and collect there as groundwater.
- Different soils have different porosity and permeability rates.
- Groundwater may move beneath the surface of the earth.

HOMEWORK:

- What determines the rate at which water will seep into the earth?
- If a farmer wanted to dig a well, how far down would he or she have to go?
- When does groundwater stop seeping downward?

ENRICHMENT:

- Research artesian wells. Draw a chart or make a model of one.
- Explain how there can be lakes in the desert, even if it doesn't rain.
- There are many sumps on Long Island. Research and report on their purpose.
- What scientific tests are used to be sure well water is safe to drink, and how often are these tests performed?

UNIT II

LESSON C9

TOPIC: The water cycle

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D6, E16, E17

PROCESS SKILLS: 1, 2, 9, 17

AIM: What is the water cycle?

MATERIALS:

- 1000mL beaker
- burner
- water
- watch glass (or any type of flat cover)
- tongs
- tripod
- Student Reference Sheet
- transparency master of Teacher Reference Sheet

PERFORMANCE OBJECTIVES: Students will be able to:

- define the water or hydrologic cycle.
- explain the water cycle.
- demonstrate how the water cycle works.

MOTIVATION:

- Place a beaker on tripod and start heating the water. When it comes to a boil elicit from students what is happening to the boiling water. After the water has come to a rolling boil, hold a watch glass or any flat cover over the boiling water. **Caution: Use tongs to prevent water vapor from scalding your hands.** Elicit from students what is going to happen. (Water droplets will begin to collect on the cover held over the boiling water.)

PROBLEM: What caused the water droplets to form and what will happen to them as they return to the boiling water?

AIM: What is the water cycle?

DEVELOPMENTAL STRATEGIES:

- Discuss with students each part of the boiling water demonstration. Heat from the burner caused the water to boil (rapid evaporation). The water vapor rises and cools. As the water vapor cools it becomes a liquid (condensation). The cover placed over the rising water vapor causes the water to cool rapidly. The water droplets that accumulate on the cover become heavier and will fall back into the boiling water. The process is then repeated.

- Distribute copies of Student Reference Sheet (a blank water cycle diagram).

- Show a transparency of the water cycle. (Use Teacher Reference Sheet.)

- Relate the falling water droplets in the demonstration to precipitation. Elicit where evaporation, condensation, and precipitation are on the diagram.

- Define the following terms: transpiration from vegetation, infiltration, and runoff. Relate them to the water cycle.

- If a closed terrarium is available, a portion of the cycle can be demonstrated with a heat lamp.

SUMMARY:

- Liquid water in rivers, lakes, and oceans is heated by the sun and evaporates to form water vapor.

- Plants also produce water vapor by transpiration through their leaves.

- The water vapor rises in the atmosphere, cools, and condenses into the water droplets of a cloud.

- Water droplets combine, become heavier, and fall to earth as precipitation.

- Some water runs off the ground into bodies of water.

- Water also enters soil and spaces in rocks by infiltration.

- Water that penetrates the ground by infiltration is called groundwater.

- Most water finally returns to the ocean.

HOMEWORK:

- Describe in general terms the water, or hydrologic, cycle.

- If water falls on loose, dry, sandy soil, infiltration will probably be greater than runoff. Explain why.

- Water falls on the city streets. More water runs off than infiltrates the ground. What is another term for this excess water?

- In what form will precipitation occur if the temperature drops to about 0°C (32°F)? Below 0°C?

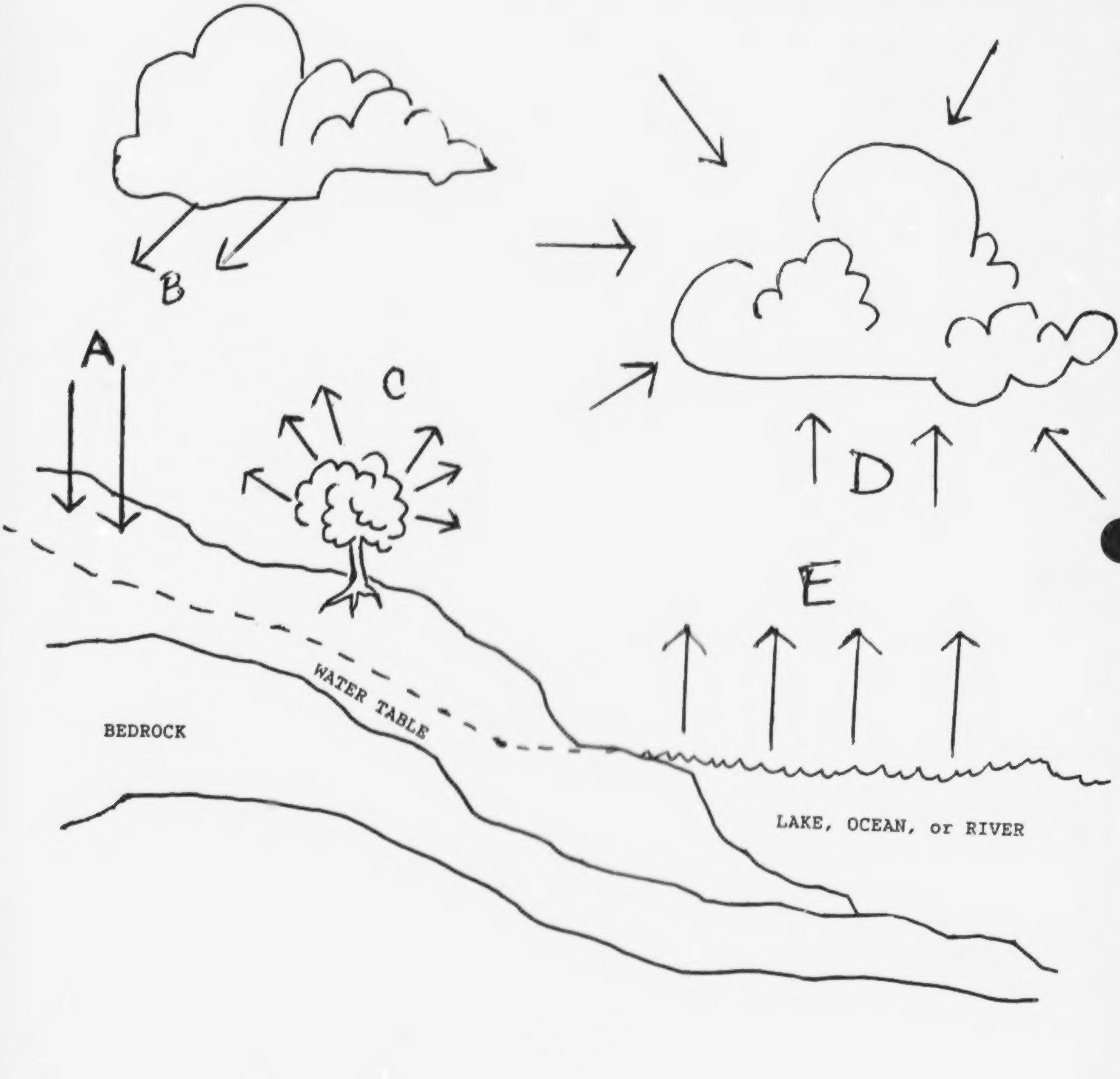
ENRICHMENT:

- The water cycle is a continuing source of fresh water. Why do some areas in the United States have a poor supply of water? Answer in terms of the water cycle.

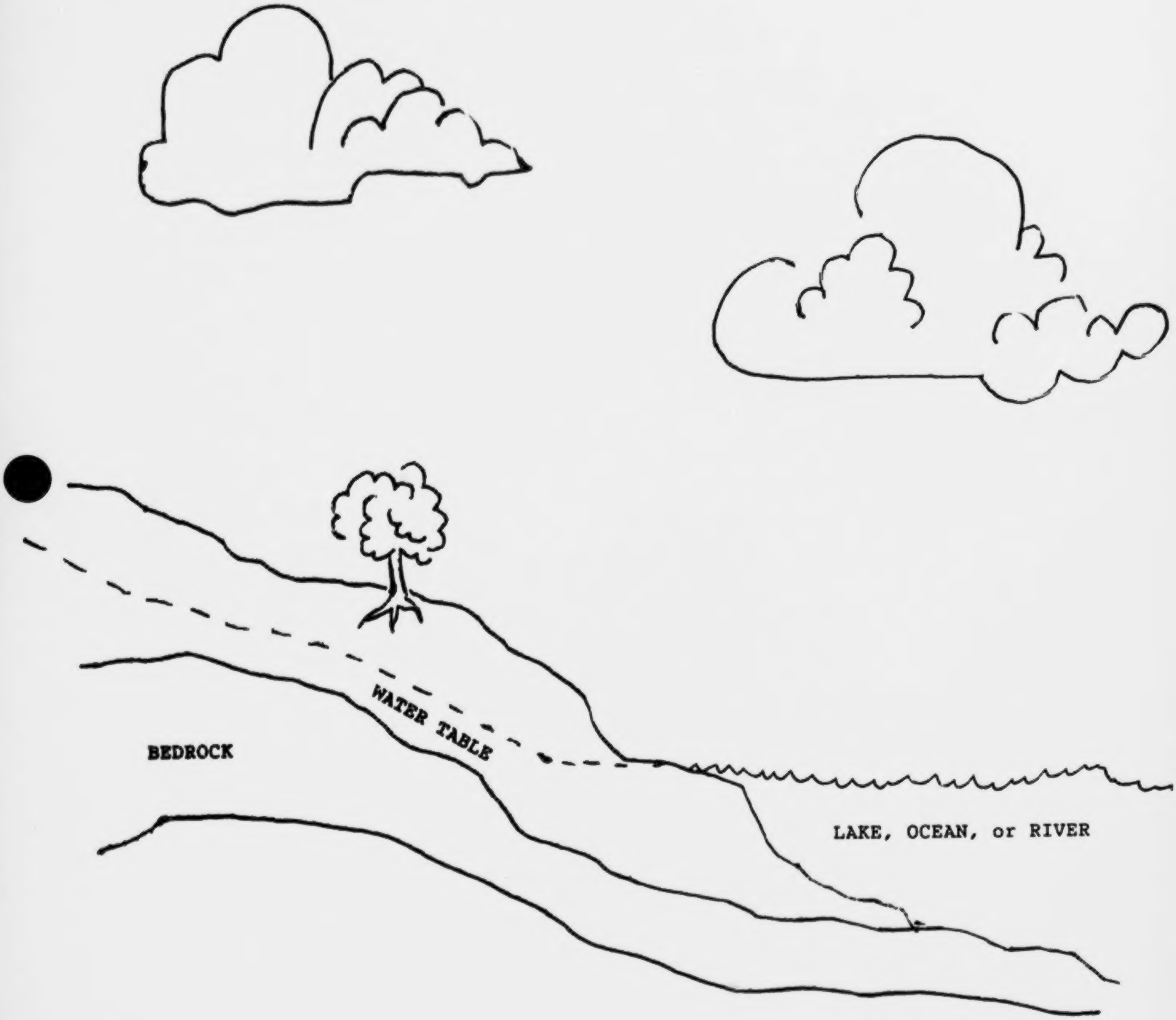
- Name some factors that might affect the water cycle.

- What effect has water pollution had on living organisms in the oceans?

The Water Cycle


B
A
C
D
E
WATER TABLE
BEDROCK
LAKE, OCEAN, or RIVER

The Water Cycle


WATER TABLE
BEDROCK
LAKE, OCEAN, or RIVER

LESSON C10

TOPIC: Life cycle of a river

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D6

PROCESS SKILLS: 1, 2, 3, 4, 5, 10, 11, 12, 13, 15, 17, 20

AIM: How does a river valley develop?

MATERIALS:

- a stream table
- pail
- protractor
- cork or paper
- sand
- copies of Student Reference Sheet

PERFORMANCE OBJECTIVES: Students will be able to:

- compare the stream table model to actual stream processes.
- describe and give examples of streams in each of the three stages of development: youth, maturity, and old age.
- correlate the characteristics of a river with the slope of the land, the velocity of the water, and its stage of development.
- summarize the characteristics of a river in each of the three stages of development.

MOTIVATION:

- Display a setup of a stream table and encourage students to develop a model of a stream or river.

or

- If no stream table is available, project a transparency of a river in each of the three stages of development and ask students to make and record observations about the slope of the land and predict what the velocity of water flow will be.

PROBLEM: How can we study stream and river development in a classroom, since we cannot bring in an entire river?

AIM: How does a river valley develop?

DEVELOPMENTAL STRATEGIES:

- After setting up the stream table, elevate the portion opposite the drain to a height of approximately 20cm. Carve a narrow trench the entire length of the sand. Start the flow of water and allow it to continue at a constant rate for about 4 minutes.

- Have the students observe the development of the channel. Elicit that the water flow is a constant, straight line and that the water is eroding the sand at a rapid rate. Be sure students note the shape of the river valley in cross section. It should be a well-defined V shape. Point out that these are some of the characteristics of a stream in its youthful stage. (You may use an appropriate diagram or overhead transparency to further illustrate these youthful stream characteristics.)

- Lower the height to 10cm. Repeat the same procedure. Elicit that the stream flow has decreased as a result of the gentle slope and that the stream is not as straight as before. The cross section is no longer a well-defined V shape. This is a model of a stream in the stage of maturity. (Use an overhead transparency or diagrams to reinforce the model.)

- Lower the stream table to a nearly horizontal position (height of 5cm). Repeat the same procedure. Elicit that the stream flow has slowed to an extremely slow rate, the erosion is now along the sides of the channel and that there appears to be a definite meander beginning to develop. The V-shaped cross section of a youthful river is now gone. This is a model of a stream that is in a stage of development called old age.

- Project a transparency or distribute copies of the Student Reference Sheet (The Life of a River) and have students summarize the characteristics of the three stages of development.

SUMMARY:

- Over a period of time, streams lengthen, widen, and lower their valleys.

- Streams pass through a series of stages in their development.

- A young river has a rapid velocity, a V-shaped valley, few tributaries, wide interstream areas, and poor drainage.

- A mature river has a decreased velocity, a wider valley, many tributaries, narrow interstream areas, flood plains, and good drainage.

- An old river has a low velocity, a very wide valley, and very wide flood plains.

HOMEWORK:

- Describe how the slope of the land affects the rate of flow of a river.

- Where would you most likely find:

  - a youthful river?
  - a mature river?
  - a river in old age?

- List five rivers on the continental United States and explain the stage of development of each.

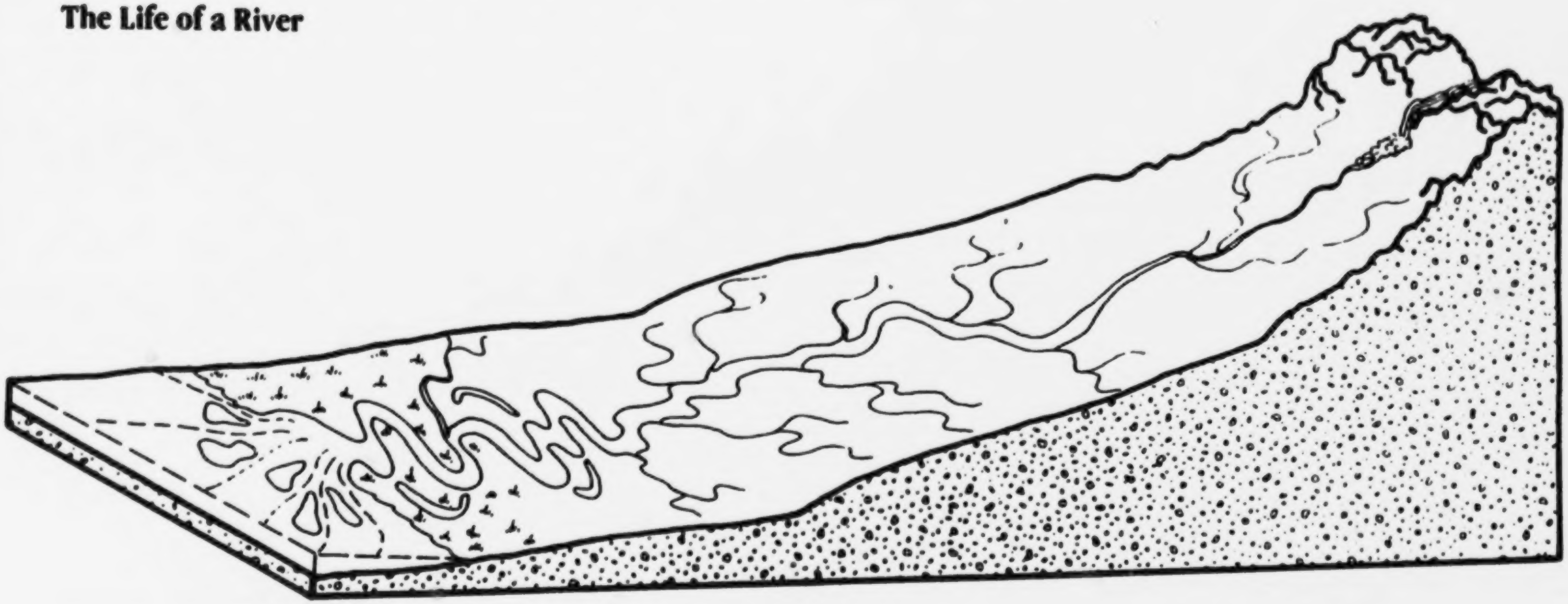
ENRICHMENT:

- Use the stream table to illustrate delta formation. (A dam of clay deposited across the lower end of the tray will cause accumulated water to develop a delta. If the clay is carefully removed, the water will drain off and show the arrangement of deposits that formed on the bottom of the accumulated water.)

- Explain why the Colorado River has gone through several stages of development more than once.

- How does an oxbow lake develop?

The Life of a River



OLD AGE

Broad flood plain
Gentle slope
Large meanders
Oxbow lakes
Levees, Deltas, Marshes
Limited, but large tributaries

ERODING FORCE

Cuts sideways to create width of channel

MATURITY

Wide valley
Moderate slope
Channel wanders
Distinct flood plain
Tributaries are common

ERODING FORCE

Cuts downward and sideways.

YOUTH

"V"-shaped channel
Steep slope
Straight channel
Few, small tributaries
Waterfalls and rapids are common

ERODING FORCE

Cuts downward

UNIT II

LESSON C11

TOPIC: Glacial erosion

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D6

PROCESS SKILLS: 1, 2, 14, 22

AIM: How have glaciers changed the surface of the earth?

MATERIALS:

- ice (slab or block)
- sand
- 10cm glass square
- bar of soap
- assorted masses (250, 500, 1000 grams)
- Student Reference Sheet (Evidence of Glacier Movement)

PERFORMANCE OBJECTIVES: Students will be able to:

- identify the characteristics of a glacier.
- explain the development of a glacier and mechanics of glacier movement.
- identify the following glacial features: striations, terminal moraine, drumlin, kame, kettle, and esker.
- recognize some local glacial features.
- identify glacial landforms from a topographic map.

MOTIVATION:

- Glaciers move downslope under gravity on a thin film of water. Demonstrate how pressure from the overlying ice melts the ice below. Place two small blocks or slabs of ice on a slightly inclined surface. Place a heavy mass on one and a light mass on the other. Observe that the cube with the heavier mass melts faster and slides down the incline sooner than the cube with the lighter mass.

- In many parts of New York City, it is possible to take a local field trip to observe glacial features like moraines, outwash plains, drumlins; e.g., Fort Tryon Park, Prospect Park, Highland Park, Central Park, High Rock.

- Photographs, slides, films, and filmstrips can be also used to illustrate a variety of glacial features.

PROBLEM: How can we explain the surface features of areas that have been eroded by glaciers?

AIM: How have glaciers changed the surface of the earth?

DEVELOPMENTAL STRATEGIES:

- Define a glacier as a moving mass of snow and ice. Explain how a glacier erodes the surface of the land. Have the class note that the ice acts as a bulldozer, moving particles in front of it. The glacier (moving ice) also has a conveyor-belt-type motion. There is motion on and in the ice that constantly shifts the glacial debris.

- Ask, "What will remain after the ice melts?" Tell the class that about one million years ago a large glacier moved down from the north to cover a good part of New York City. Sections like Crown Heights and Highland Park in Brooklyn are located on top of the mound produced by this glacier. The mound is called a terminal moraine.

- To show how a glacier affects the surface over which it moves, place some sand on an ice cube and move the cube across a piece of soap. (This also works with a glass square.) Have the class examine the soap and elicit that as a glacier moves, bits of sand or gravel embedded in the glacier will scratch and groove the surface it touches. Tell students that fine particles will smooth and polish the surface over which it moves. Show students specimens or pictures of rocks with striations.

- Distribute copies of the Student Reference Sheet, Evidence of Glacier Movement (or make it into a transparency). Inform students that, in the study of glacier movement, stakes are driven in straight rows across the glacier and their positions are recorded over some time period. Ask, "What does the diagram point out about glacier movement?" Elicit that a glacier moves faster in the center than at its edges. Guide them to see that the reduction in speed is due to friction between the ice and the surface along which the glacier moves.

- Elicit that if the snowfall in an area exceeds the amount of snow that melts, the snow will accumulate. Point out that as new snow piles on top of old snow, pressure will be produced; this pressure will cause the snow to melt. Remind the students of what happened in the motivational demonstration.

- Demonstrate that water formed around ice will refreeze. Apply pressure to two ice cubes held together. Show students that they will stick together. Elicit that the pressure melts some of the ice between the cubes. When the pressure is removed, the water refreezes. Have the students recall that as you compress a snowball, it hardens and eventually changes to ice.

SUMMARY:

- A glacier is a slowly moving mass of ice that has been formed by the decrystallization of snow.

- Glaciers form where winter snowfall exceeds summer melting. Freezing and thawing and increasing presure change the accumulated snow to ice.

- Valley glaciers form in valleys in mountainous areas.

- Continental glaciers are thousands of meters thick and cover large areas, burying hills and valleys.

- Moving ice, carrying rock fragments which act like cutting tools, erodes the surface over which it passes. (Students should infer that valley glaciers create rugged terrain by removing rocks from steep slopes, while continental glaciers level the land by removal or deposition of rock.)
- Glaciers produce striations or scratches on the rocks over which they move, indicating the direction in which the glacier is moving.
- Glaciers move in response to gravity, from a few centimeters to as much as 1 meter per day.

HOMEWORK:

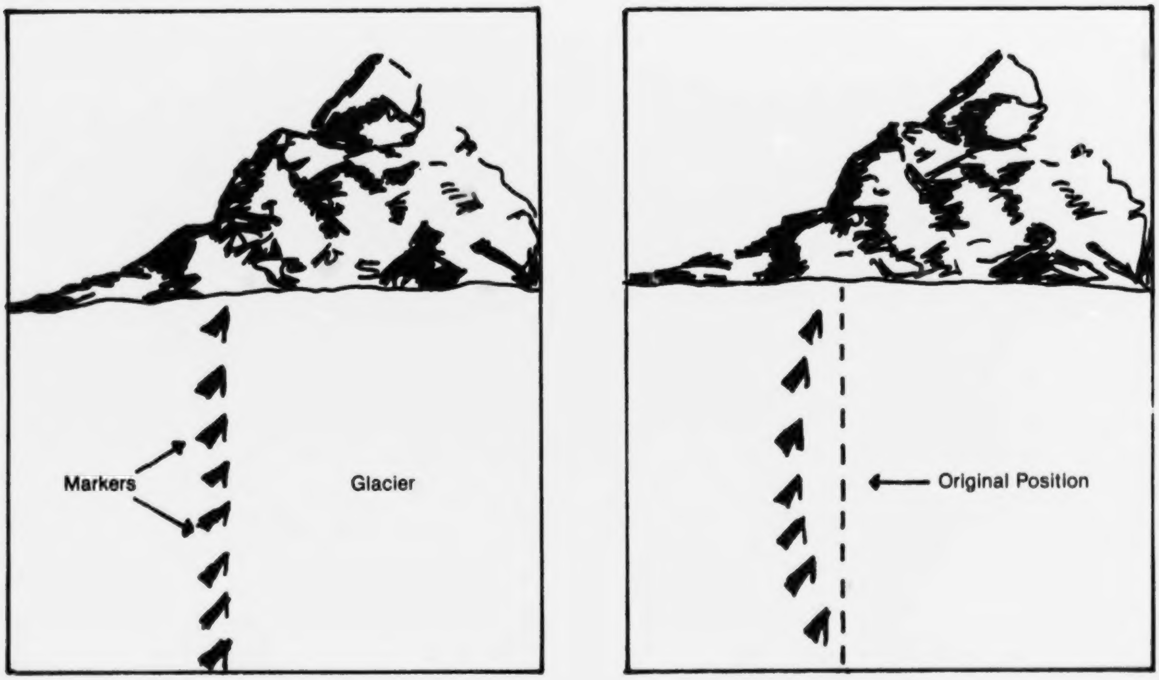
- The north shore of Long Island is very different from the south shore. Describe the features you may find on the north shore and explain how they were formed.
- Explain how a glacier can grow smaller and finally disappear.
- Where are glaciers found?
- Why does the snow melt faster on a street with a great deal of traffic?
- Is glacial ice like a thin sheet of ice which freezes in a puddle? Explain your answer.

ENRICHMENT:

- Use quadrangle topographic maps of the following to illustrate glacial features. (These maps may be purchased from the National Geographic Society, Washington, D.C.)

Feature	Quadrangle
Drumlins	Weedsport, NY Palmyra, NY
Eskers	Saranac Lake, NY Passadumkeag, ME Rouses Point, NY Fowlerville, MI
Kettles Terminal moraine Outwash plain Kettle lakes Kames	Brooklyn, NY Hempstead, NY
Finger Lakes	Watkins, Geneva, Penn Yan, Hammondsport, Naples, NY
Aretes Matterhorn peaks Hanging valleys Cirques Tarns U-shaped valleys	Mount Whitney, CA Chief Mountain, MT

Evidence of Glacier Movement


Markers
Glacier
Original Position

A

B

In the study of glacier movement, stakes are driven in straight rows across the glacier and their positions are recorded over some time period.

LESSON C12

TOPIC: Wind erosion

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D47/D6

PROCESS SKILLS: 1, 2

AIM: How does wind change the surface of the earth?

MATERIALS:

- sandpaper
- a piece of wood
- electric hair dryer
- large world map
- large carton
- two plastic trays
- 1/2 kg of fine sand
- large pictures of balancing rocks and other wind-eroded features (travel posters)

PERFORMANCE OBJECTIVES: Students will be able to:

- explain how wind erodes the surface of the earth.
- describe the locations where wind erosion is the most significant.
- describe the appearance of wind-eroded areas.

MOTIVATION:

- Using sandpaper, sand a rough piece of wood. Discuss with students how a powder is produced.

PROBLEM: How can wind act on the earth in a way similar to the way sandpaper acted on wood?

AIM: How does wind change the surface of the earth?

DEVELOPMENTAL STRATEGIES:

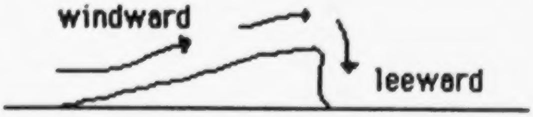
- Elicit that wind causes sand particles to wear away the surface of the earth. Discuss with students how some buildings are cleaned by sand blasting. Have students recall how their faces sting when the wind blows sand or street dirt at them. Show students pictures of balancing rocks and wind-sculptured rocks. (Desert areas will show these features best.)
- With an electric hair dryer on its coolest setting, blow air across a pile of dry sand and moist sand. Point out that the dry sand was moved more easily than the moist sand. Elicit that wind erosion will take place most often in dry regions. Display a world map and ask the class to locate dry regions on the earth where wind erosion is now taking place.

- Demonstrate how a sand dune is formed by pouring a pile of sand on the bottom of a large carton. Direct the hair dryer toward the pile of sand. Then place an obstacle, such as a pencil, in the path of the blowing sand and have students observe how a dune is formed.

NOTE: As in all other demonstrations, be sure to try this yourself before class so that you will be able to correctly gauge the optimum height and angle of the hair dryer.

- Be sure students observe the gentle slope on the windward side and the steep slope of the leeward side. Show the class pictures of desert scenes, including sand dunes. Discuss with students their experiences with sand dunes at such places as the Long Island, Brooklyn or Queens beaches.

- Show students the migration of a sand dune and the problems that it causes for nearby roads and homes. On the chalkboard, draw a diagram similar to the one below.



- Ask the students if they are able to explain how we can stabilize sand dune migration. (Some students may be able to recall dune grass being planted at the beaches, or the use of snow fences to keep sand back.)

SUMMARY:

- In dry regions, wind will drive bits of rock material against other rock surfaces and erode them.

- An obstruction or a decrease in speed may cause the wind to deposit its material and form a dune.

- A sand dune migrates in the direction of the wind.

- Vegetation often prevents the wind from transporting surface material.

HOMEWORK:

- In what kind of climate is the wind most effective as an agent of erosion?

- Describe the formation of a sand dune.

- Explain the migration of a sand dune.

- Where in New York State would we find evidence of wind erosion?

- You are traveling in the desert and you come across a telephone pole that has a pile of rocks at its base. Explain why they may have been put there.

ENRICHMENT:

- Find out more about sand blasting. Contact a company that does sand blasting, and report on the strength of the air stream, and how the process works.
- Find out about the desert of Maine. How did it form and why is it special?
- How are people affected by the migration of sand dunes? Write to the Cape Cod National Seashore or Fire Island National Seashore and report about their sand-clearing operations.

UNIT II

LESSON C13

TOPIC: Formation of soil

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D, D2

PROCESS SKILLS: 1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 14, 17

AIM: How is soil formed?

MATERIALS:

- large and small pieces of limestone, shale, and marble
- beakers with samples of potting soil, sand, clay
- funnels, ring stand, ring, water, stopwatch, filter paper
- commercial boxes illustrating soil formation

PERFORMANCE OBJECTIVES: Students will be able to:

- define weathering and erosion.
- explain soil formation.

MOTIVATION:

- Show photographs or other pictures of fertile and nonfertile regions. Ask students to compare and contrast these regions. Elicit why they think certain plants grow in one region and not in another.

PROBLEM: What happens to weathered and eroded rock fragments over a long period of time and why will plants grow in some areas but not in others?

AIM: How is soil formed?

DEVELOPMENTAL STRATEGIES:

- Rub two pieces of limestone or shale together. Have students note that smaller particles are produced. Display several samples of weathered and unweathered rocks. Ask students if they can explain what caused some of the samples to weather. (As soon as a surface becomes exposed to the elements it begins to weather.)

- Display commercially prepared boxes showing soil samples formed from specific types of bedrock. Elicit that different minerals form different kinds of soils (limestone-rich soil forms from limestone bedrock; granite soil forms from granite bedrock). Soils formed from underlying rock are called residual soils. Soils may also be transported from one location to another by the various agents of erosion. Transported soils are different from the underlying rock.

- Discuss permeability (rate at which water penetrates porous materials). Explain that the rate at which water moves through soil affects the rate of weathering and the fertility of the soil. (See Laboratory Sheet and experiment.)

- Air and moisture become trapped in loose soils. This becomes an ideal place for some plants and animals to live. As they die, they create a rich organic base for other plants and animals. Very dark soil is rich in organic matter. The organic matter in soils is called humus.

- The activities of animals, the action of freezing and thawing, the force of gravity, the work of streams, and many other factors are continually wearing rocks away. With the aid of plants, the dust that is worn from the rocks may eventually become good soil.

- Elicit other conditions besides the action of living organisms that make good soils (climate, topography or slope of the land, chemical composition of underlying rock, length of weathering time, etc.)

- Soils are generally classified by climate and types of local vegetation.

- Soils in temperate, humid climates with a forest cover are light colored with a dark, organic upper surface. Subhimid climates with grasslands promote dark-colored soils high in organic matter. Light-colored soils, rich in carbonates, form in shrub-covered, arid regions.

- Gray and yellow surface soils are low in natural productivity. Red surface soils are commonly more productive, but brown and black soils have the greatest natural fertility.

- Although clay has about twice the pore space as an equal volume of sand, it is quite impermeable because the pores are very small.

- Call attention to the long period of time needed to form good soil and the need for conserving it. Grass fires, forest fires, and wasteful farming practices remove the cover of vegetation from the soil. Discuss various means of preventing erosion and conserving the soil.

SUMMARY:

- Soil is a product of both physical and chemical weathering.

- Soil forms from rock fragments by the slow processes of weathering, accompanied by the growth and influence of living things.

- Soil is composed of minerals, water, and organic compounds.

- Soils are classified according to climate and the type of vegetation they will support.

- Soil productivity depends on the fertility and the physical condition of the soil.

- Continued productivity of the soil depends upon returning to the soil minerals removed by plant growth.

HOMEWORK:

- What is soil?

- How do soils differ from each other?

- What is a soil profile?
- Why is soil important to all living things?
- What is organic material?
- Why does water move faster through sand than clay?
- What gives topsoil its dark color?

ENRICHMENT:

- Gather soil cross-sections from your neighborhood and prepare reports on what type of soil profiles you have collected.
- Write to local and national organizations and prepare a report or short talk on the local and national problems of soil erosion and efforts being made to protect soils (soil conservation).

STUDENT LABORATORY SHEET

PROBLEM: Which soils will transmit water fastest?

HYPOTHESIS: Loose, large-particle types of soil have a greater rate of water infiltration than compacted, smaller-particle soils.

MATERIALS AND EQUIPMENT: Ringstand, ring, funnels, filter paper, stopwatch, 250ml beakers, samples of limestone or marble chips, sand, clay, graduated cylinder

PROCEDURE:

- Set up three ring stands with funnels and filter paper. Add limestone or marble chips to one of the funnels until it is 3/4 full. Add the same amount of sand to the second funnel and the same amount of clay to the third funnel.
- Pour 100ml of water into each funnel and time how long it takes for the first drop to reach the beaker.
- Record results in data collection table below.

DATA COLLECTION:

Particle Size	Time for first drop to appear
Large (limestone or marble)	
Medium (sand)	
Small (clay)	

CONCLUSIONS:

- Was your hypothesis correct? (Yes/no)
- Did we solve the problem? (yes/no)
- Prepare a graph of your results.
- Why don't plants grow well in clay soils?____________________

____

____

- Why does water at the shoreline at the beach disappear into the sand so quickly?____________________

____

LESSON C14

TOPIC: Prevention of erosion

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D1, D6

PROCESS SKILLS: 1, 2, 9, 10, 14, 20

AIM: How can we control erosion?

MATERIALS:

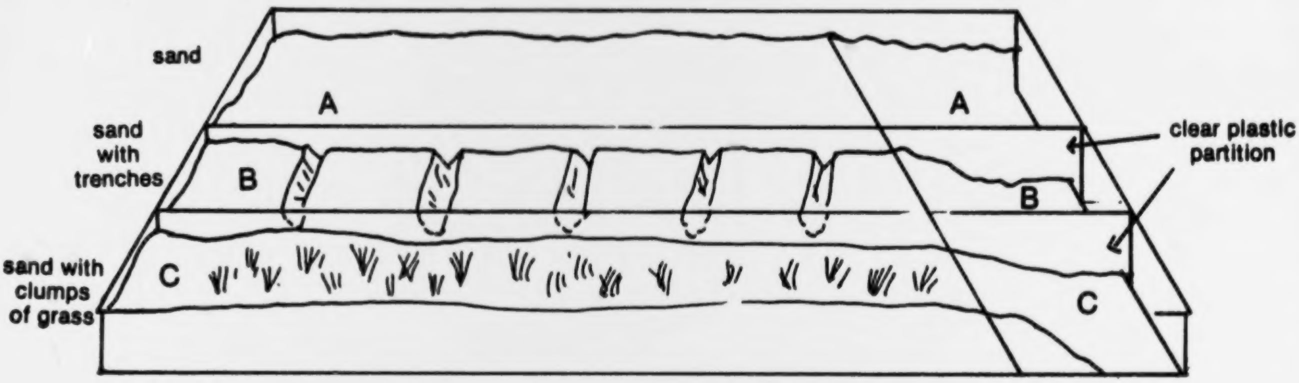
- stream table kit with rainmaking device
- overhead transparencies of erosional effects

PERFORMANCE OBJECTIVES: Students will be able to:

- identify running water as the greatest agent of erosion.
- demonstrate methods of reducing the rate of erosion.
- analyze the effectiveness of erosion controls.
- give examples of methods of slowing erosion.

MOTIVATION:

- Set up the stream table as illustrated in the diagram below.



In each of the three partitions place the following materials:

- stream-table sand only; smooth it out as flat as possible.
- stream-table sand only, with V-shaped trenches.
- stream-table sand with clumps of dried grass embedded in the sand.

- Place a rainmaking device above the stream table or use a shower head connected to a water supply.

PROBLEM: If erosion cannot be stopped, what can we do to limit its effects?

AIM: How can we control erosion?

DEVELOPMENTAL STRATEGIES:

- Elicit that water travels from higher to lower elevation and that the running water can't be stopped since we cannot control the weather.

- Elicit that once the flow of water is started, erosion is inevitable.

- Ask the students to predict whether or not there will be any difference in the rate of erosion in the three model landscapes.

- Place several predictions on the chalkboard and have the students support them with some logical arguments.

- Begin the demonstration and have students observe the effect of the artificial rainstorm on the three surfaces. Have students record their observations.

- After 5 minutes examine the results. There should be significantly more erosion on the smooth sandy surface than on the other two.

- Check the predictions made by the students and have them analyze the accuracy of their predictions.

- Point out that these models represent processes that occur on the earth's surface and that the procedures used to slow down erosion are similar to the formation of V-shaped trenches and planting of grass on the stream table. Discuss how contour plowing, terracing, and planting vegetation (grass, etc.) are used to slow the effects of erosion.

- Elicit other methods used to control the flow of running water; e.g., dams.

SUMMARY:

- Erosion by running water is a natural process and occurs whenever water moves from any elevation toward sea level. It cannot be stopped, but its speed may be slowed or controlled.

- Conservation of many of our natural resources depends largely upon slowing the rate of erosion by reducing the volume and/or velocity of the water.

HOMEWORK:

- List and explain at least three methods that can reduce the flow of running water and slow the rate of erosion.

- Why can't we stop erosion?

- How does slowing down the velocity of water reduce the rate of erosion?

ENRICHMENT:

- Carry out a research project on three major dams in the United States.
- Find out about attempts to save the Montauk Lighthouse.

UNIT II

LESSON D1

TOPIC: The rock record

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D7, D8

PROCESS SKILLS: 1, 2, 9, 17

AIM: What is the rock record?

MATERIALS:

- mineral samples: sandstone, limestone, salt, schist, obsidian, gneiss, pumice
- fossils of plants or marine animals
- photos: desert sand dunes, glaciers, beaches, V-shaped valleys, U-shaped valleys, islands, volcanoes, mountains

PERFORMANCE OBJECTIVES: Students will be able to:

- explain how the composition, position, and fossil content of rocks give clues as to how they were formed.
- explain the concept of uniformitarianism.
- identify the age of the earth to be about 5 billion years.

MOTIVATION:

- Display or distribute pieces of sandstone. Ask the class to form a hypothesis concerning its origin. Other specimens of rock that could also be utilized include: rocks containing marine or plant fossils; salt, limestone, obsidian, pumice, schist, and gneiss.

PROBLEM: How can the rocks found on earth today be useful in determining what went on in the past?

AIM: What is the rock record?

DEVELOPMENTAL STRATEGIES:

- Information about the earth contained in rocks is known as the rock record. Elicit hypotheses for the formation of sandstone, i.e., sandstone was formed by the cementation and compaction of sand grains. Ask students if they think sandstone may be forming today. Elicit that the processes which are working today to form sandstone were also at work in the past. The theory of uniformitarianism states that the processes working on earth today existed in the past. This theory leads to the conclusion stated by the Scottish geologist James Hutton, "The present is the key to the past."

- Students should be challenged to develop hypotheses concerning the formation of other types of rocks and fossils, e.g., mud was needed for the formation of shale, footprints and leaf prints were probably formed in sediments, gneiss and schist require huge amounts of heat and great pressure, salt required an arid environment.

- Features associated with modern glaciers (U-shaped valleys, unsorted sediments, morains, outwash plains), rivers (sorted and rounded sediments, flood plains), deserts (dunes), beaches (ripple marks), mountains (folded strata, metamorphic rocks) may be found in the earth's rock record.

- Elicit that the rock record gives us an understanding of what occurred in the earth's past.

- According to the latest data, the earth is believed to be about 5 billion years old. (This information comes from radioactive dating.) Ask how the earth could have formed. Develop hypotheses for the earth's formation: a star passed close to our sun and pulled away gaseous materials which later formed planets; the earth formed along with other planets when a huge rotating mass of gas and interstellar "dust" condensed; etc.

SUMMARY:

- The rock record indicates what has happened in the past.

- Uniformitarianism states that the same processes that are forming features on the earth today were also taking place in the past.

- The planet earth is about 5 billion years old.

- Two hypotheses explaining the formation of the earth are: a) a star passed close to our sun and pulled away gaseous materials which later formed planets; and b) the earth formed along with other planets when a huge rotating mass of gas and interstellar "dust" condensed.

HOMEWORK:

- Explain how the idea that "the present is the key to the past" helps to explain the earth's history.

- What would the discovery of fossil ferns in Antarctica tell you about that continent's past?

- Evidence exists that meteorites and the moon are the same age as the earth. What hypotheses or conclusions do you reach from that evidence?

ENRICHMENT:

- Report on the rock record of the Grand Canyon.

- Report on the origin of the planet earth.

- Report on the early history of the earth.

- Describe the geologic history of New York State or New York City as illustrated by the rock record.

LESSON D2

TOPIC: Relative age of rocks

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D8

PROCESS SKILLS: 1, 2, 14, 17

AIM: How can we tell the relative age of rocks?

MATERIALS:

- Reference Sheets 1, 2, and 3

PERFORMANCE OBJECTIVES: Students will be able to:

- explain the law of superposition.
- describe an index fossil.
- interpret the geological history of rock layers.
- describe how an igneous intrusion indicates relative age.
- show how a rock layer indicates faulting, erosion, or deposition.
- explain why fossils of marine plants or animals are found in rock high above sea level.
- compare and contrast absolute age to relative age.

MOTIVATION:

- Using transparencies or other visual aids, show the students block diagram 1 from Reference Sheet 1. Ask students if they can determine the age of the rock.

PROBLEM: There are two general ways for determining the age of a rock. One is relative age, comparing the age of one rock with another. The other is absolute age, knowing the age of a rock in years. What clues helps us to determine the relative age of rocks?

AIM: How can we tell the relative age of rocks?

DEVELOPMENTAL STRATEGIES:

- Distribute Reference Sheet 1 to each student. Ask students if they can determine the absolute or relative age by examining the diagrams. Responses should indicate that there is no visible evidence of absolute age, but there is much evidence concerning relative age.

- Ask students to determine the relative age of the rock layers in the various block diagrams. Require the students to defend their answers. Record their responses on the chalkboard. The evidence of relative age includes the following:

- The law of superposition states that rock material on the bottom (if undisturbed) is older than rock material on the top. Example: If newspapers are collected and stored one day at a time, the oldest paper is on the bottom and the most recent is on the top.

- Magma intruding into a rock is younger than the rock into which it intrudes.

- Faulting can cause part of rock strata to move up or down. The rock had to have been in place before the fault occurred.

- If a horizontal stratum undergoes folding, the folding must have occurred after the horizontal layer was in place.

- Evidence of erosion includes a missing layer or layers (an unconformity).

- Contact metamorphism occurs after the intrusion of magma. (The heat of the intruding magma can change the rock it touches. This type of local metamorphism is called contact metamorphism.)

- Finding marine fossils in rock high above sea level indicates that the land has risen. (If all the water on earth now stored as ice melted, sea level would rise only a few hundred feet. This is not enough to cover rock high above sea level.)

- The type of fossil gives clues about the climate and environment of the area at the time the fossil was deposited. Examples: Fossil coral indicates a warm marine environment; mastodon remains indicate a cold land environment.

- Index fossils are helpful in determining the relative age of other fossils or rocks. They have the characteristics of wide horizontal range and narrow vertical range. Index fossils are of creatures that lived over a wide geographic area but for only a short period of geologic time, and they are relatively common and are easy to identify.

SUMMARY:

- The relative age of sedimentary strata is usually indicated by position; the oldest rock layer is normally on the bottom, the most recently deposited layer on the top. This is commonly referred to as the law of superposition.

- Intrusions of magma occurred more recently than the rocks into which they intrude.

- The rock record shows evidence of crustal uplifts followed by long periods of erosion and deposition.

- Fossils of marine animals and plants are often found in rock high above sea level.

- Fossils often indicate the development of life, climates of the past, and the conditions under which the fossils formed.

- Index fossils (fossils of organims that existed for only a short period of time and were relatively abundant in a widespread area) are useful in identifying the relative age of rocks in widely separated areas.

HOMEWORK:

- Distribute Reference Sheet 2 and ask students to:
  - reconstruct the history illustrated by the rock record. The layers should be organized from oldest to youngest.
  - explain whether the magma intrusion labeled A occurred before or after the fault.
  - determine where and when contact metamorphism would occur. It is not shown on the diagram.
  - discuss what the contact between C and D illustrates.

ENRICHMENT:

- Report on the use of a specific index fossil.
- Explain why no one place on earth has a complete unbroken rock record of the earth's history.
- Write a report on the Scottish geologist James Hutton.

REFERENCE SHEET 1

Key for all diagrams:

▦ = Limestone

▤ = shale

⁙ = sandstone

▨ = Igneous rock

⟋ = contact metamorphism

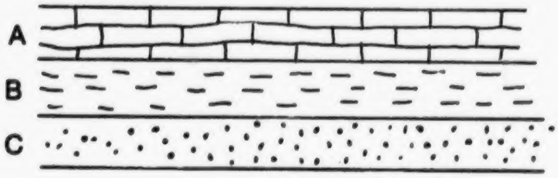


Diagram #1

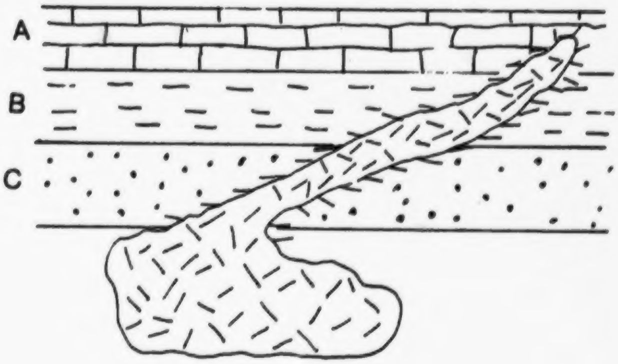


Diagram #4

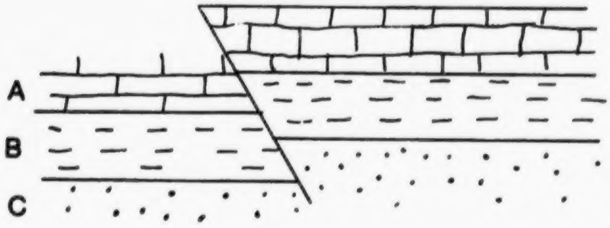


Diagram #2

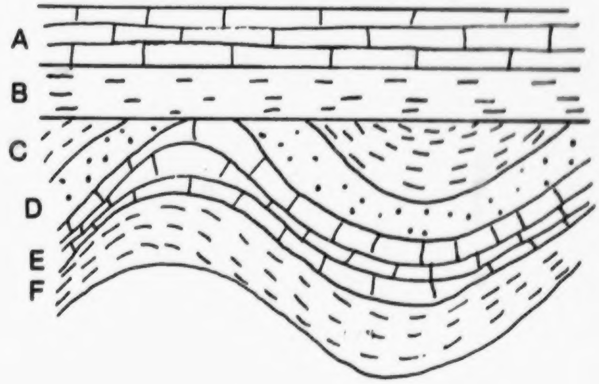


Diagram #5

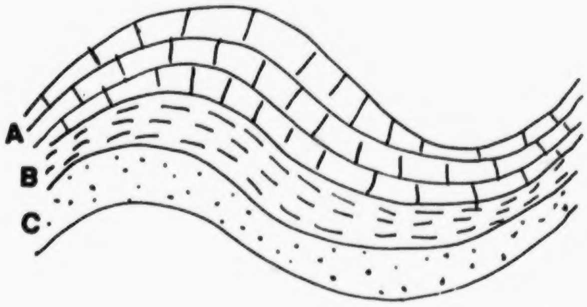


Diagram #3

REFERENCE SHEET 2

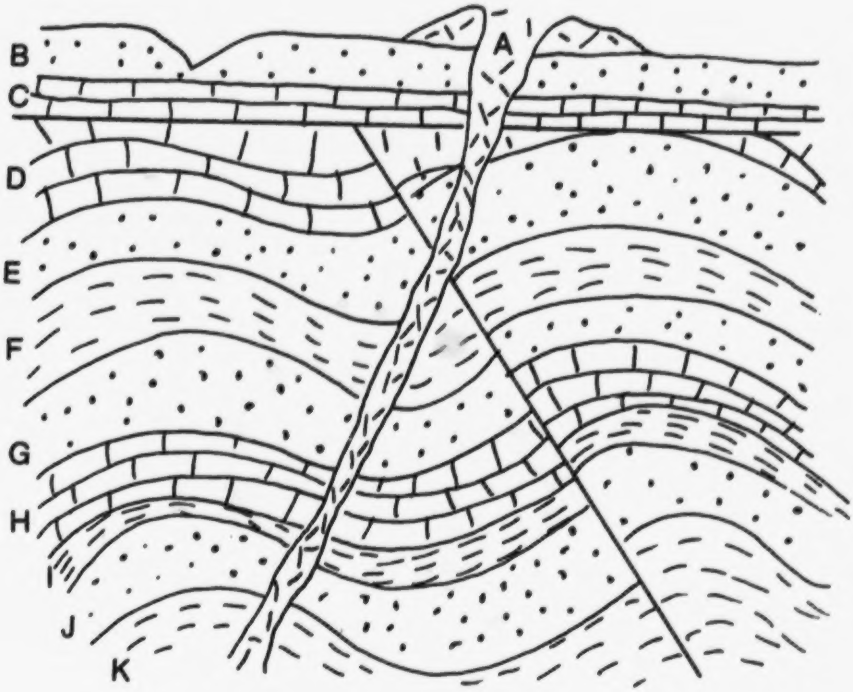
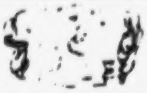
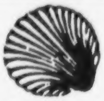
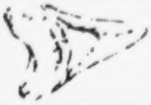
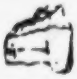
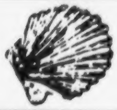
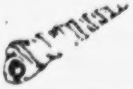
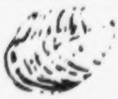
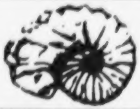
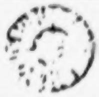
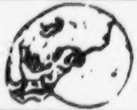
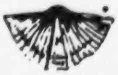
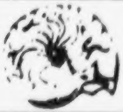
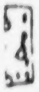
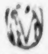
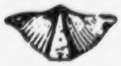
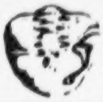
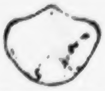
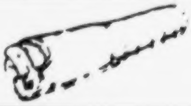
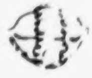

A
B
C
D
E
F
G
H
I
J
K

Diagram #6

UNIT II
Lesson D2

REFERENCE SHEET 3

INDEX FOSSIL CHART

Common Fossils	Geologic Age	
EQUUS TOOTH 	Recent	5
VENERICARDIA  **CARCHARODON TOOTH** 	Recent to Miocene	2, 20
MERYCHIPPUS TOOTH  **PECTEN**  **TURRITELLA** 	Miocene	14, 19
OLENEOTHYRIS 	Eocene	13
ACANTHOSCAPHITES  **TETRAGAMMA** 	Cretaceous	1, 18
MEEKOCERAS 	Triassic	7
NEOSPIRIFER	Pennsylvanian	12
SPIRIFER  **MUENSTEROCERAS**  **CRINOID STEM**  **PENTREMITES** 	Mississippian	11
MUCROSPIRIFER  **PHACOPS** 	Devonian	10, 16
EOSPIRIFER 	Silurian	4
MICHELINOCERAS  **FLEXICALYMENE** 	Ordovician	

LESSON D3

TOPIC: Absolute age of rocks

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D

PROCESS SKILLS: 2, 3, 5, 9, 11, 12, 13, 14, 15, 20

AIM: How can we determine the absolute age of a rock?

MATERIALS:

Per lab group and demonstration:
- geiger counter, if available
- 100 pennies
- 100 dried corn kernels
- cardboard box with lid

PERFORMANCE OBJECTIVES: Students will be able to:

- explain the concepts of radioactive dating and half-life.
- appraise an experiment designed to demonstrate half-life.

MOTIVATION:

- Using visual aids, demonstrate the idea of radioactive decay. Radioactive decay occurs when radioactive elements change into new elements by giving off energy and particles. This process takes place at a steady, constant rate. The rate of decay is not affected by outside factors such as changes in temperature, pressure, or phase. This rate is often expressed as half-life, or the time it takes for half the mass of a radioactive element to decay. Thus, if a rock or fossil contains a radioactive element, the decay process may be used like a clock to determine its age. Examples: carbon 14 decays into nitrogen 14, half-life of 5,700 years (it would take 5,700 years for half of C-14 to decay into N-14); uranium 238 decays into lead 206, half-life of 4.5 billion years.

PROBLEM: How can we develop a model that would demonstrate how radioactive decay and half-life can determine the absolute age of a rock?

AIM: How can we determine the absolute age of a rock?

DEVELOPMENTAL STRATEGIES:

- Show the class a box of 100 pennies, all with the same side up. Ask students to design an experimental model using the 100 pennies that would represent the decay of a radioactive element.

- Students need to suggest a method of decay that is unaffected by outside forces and is based strictly on the laws of probability.

- Record student responses on the chalkboard. Responses should include shaking or tossing the box as a mechanism of decay. All pennies that have turned over are said to be decayed and should be removed. (Each shake or toss represents a certain amount of time. The number of shakes necessary to "decay" half of the pennies would be the half-life.)

- Distribute Student Laboratory Sheets and materials to each of the lab groups and discuss the procedure and method of recording data.

- If a double period exists for this laboratory exercise, a second example of radioactive decay can be demonstrated using corn kernels. (If no double period is available, continue with the corn kernels the next available period.) After the penny experiment is completed, the students should use the corn kernels as an example of a different radioactive material.

SUMMARY:

- The absolute or actual age of many rocks can be determined by radioactive dating.

- Models representing radioactive decay and half-life can be shown using pennies and corn kernels.

HOMEWORK:

- How did the average percentage of pennies and corn kernels that decayed per shake compare? What accounts for the difference?

- Using the results from the question above, assume that each shake represented one million years. What is the half-life of the penny model? The corn kernel model?

- Would increasing or decreasing the number of pennies or corn kernels affect the half-life? Explain your answer.

ENRICHMENT:

- Repeat the experiment at home using 200 pennies, and report on your results.

- Repeat the experiment at home using 50 pennies and report on your results. (Note that with small numbers the results may fail to resemble the normal distribution.)

- Report on how geologists or paleontologists determine the age of a rock using uranium 238/lead 206 dating.

- Report on how archeologists or paleontologists report on the age of a specimen using carbon 14 dating.

PROBLEM: Using a model, how can we represent how radioactive decay and half-life determine the absolute age of a rock?

HYPOTHESIS: There is a 50% chance that the penny will turn over.

Background Information

Pennies -- Using pennies all facing the same way in a box, we can represent a radioactive material decaying. The pennies are the radioactive material. When we shake or toss the box each penny has a chance of facing the same way or turning over. This chance will represent the decay rate. There is a 50% chance that the penny will turn over. Half-life is the amount of time necessary for half of a radioactive material to decay. Each shake will turn approximately half of the pennies over and we will remove them. Thus, each shake of the pennies represents the half-life.

Corn Kernels -- The corn kernels have a pointed side. Mark an X on one side of the box. Shake the box and remove all the kernels pointing to the side marked X. Since the box has four sides there is a 1 in 4 chance that the kernels will point to the side marked X. Thus, each shake should result in 25% of the kernels pointing to the side marked X. Remove those kernels after each shake. Since one shake removes approximately 25% of the kernels, the half-life (which is represented by how many shakes it will take to remove 50% of the kernels) is two shakes.

MATERIALS:

- box with lid, corn kernels, pennies

PROCEDURE:

Pennies:

1. Place 100 pennies in the box with the same sides up (e.g., all heads). Cover the box, hold it level, and shake it vigorously. Open the box and remove all pennies that have flipped over. Record the number of pennies left in the box.

2. Repeat step 1 until no more pennies are left in the box.

3. Graph your data obtained from steps 1 and 2; plot number of shakes vs. number of unflipped pennies left in the box.

4. Repeat step 3, but use class data in which the entire number of pennies left in all the boxes after each shake has been totaled.

Corn Kernels:

1. Place 100 kernels in the box, and mark one of the sides with an X. Cover the box, hold it level, and shake vigorously. Open the box and remove all the corn kernels that pointed to the side marked X. Record the number of corn kernels left in the box.

2. Repeat step 1 until no more corn kernels are left in the box.

3. Graph your data obtained from steps 1 and 2; plot number of shakes vs. number of corn kernels left in the box.

4. Repeat step 3 but use class data in which the entire number of corn kernels left in all the boxes after each shake has been totaled.

DATA COLLECTION:

See attached charts and graphs.

CONCLUSIONS:

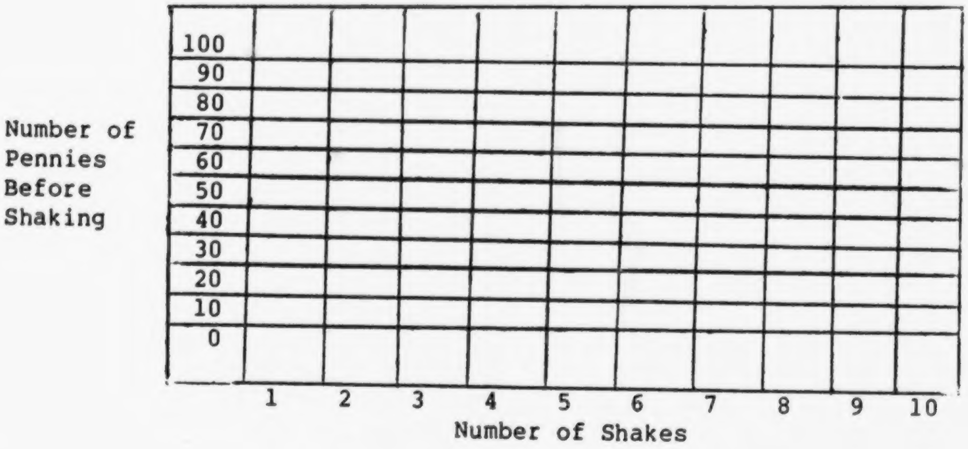
1. The pennies should "decay" at the rate of each shake removing 50% of them. This means that the shake is equal to the half-life. If each shake represented 1,000 years, then the half-life of the pennies would be 1,000 years.

2. The corn kernels should "decay" at the rate of each shake removing 25% of them. This means that it should take two shakes to remove 50% of the corn kernels. If each shake represented 1,000 years, then the half-life of the corn kernels would be 2,000 years.

PENNIES

Shake Number	Number of Pennies Before Shaking Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	Gr. 6	Class Average
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							

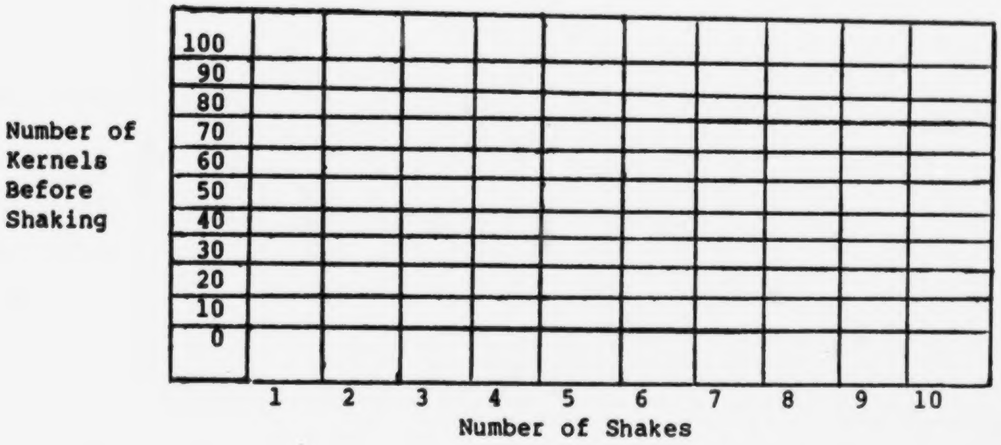
Graph (Class Average Data)



CORN KERNELS

Shake Number	Number of Corn Kernels Before Shaking						Class Average
	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	Gr. 6	
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							

Graph (Class Average Data)



UNIT II
Lesson D3

STUDENT LABORATORY WORKSHEET
(page 1 of 3)

NAME ____________________ CLASS ____________ DATE __________ LAB GROUP # ____

PROBLEM: Using a model, how can we represent how radioactive decay and half-life determine the absolute age of a rock?

HYPOTHESIS: ____

____

MATERIALS:

. box with lid, corn kernels, pennies, graph paper

PROCEDURE:

Pennies:

1. Place 100 pennies in the box with the same sides up (e.g., all heads). Cover the box, hold it level, and shake it vigorously. Open the box and remove all pennies that have flipped over. Record the number of pennies left in the box.
2. Repeat step 1 until no more pennies are left in the box.
3. Graph your data obtained from steps 1 and 2; plot number of shakes vs. number of unflipped pennies left in the box.

Corn Kernels:

1. Place 100 kernels in the box, and mark one of the sides with an X. Cover the box, hold it level, and shake vigorously. Open the box and remove all the corn kernels that pointed to the side marked X. Record the number of corn kernels left in the box.
2. Repeat step 1 until no more corn kernels are left in the box.
3. Graph your data obtained from steps 1 and 2; plot number of shakes vs. number of corn kernels left in the box.

DATA COLLECTION:

Use attached charts and graphs.

CONCLUSIONS: ____

____

____

____

UNIT II
Lesson D3

STUDENT LABORATORY WORKSHEET
(page 2 of 3)

NAME ______________________ **CLASS** ____________ **DATE** _________ **LAB GROUP #** ____

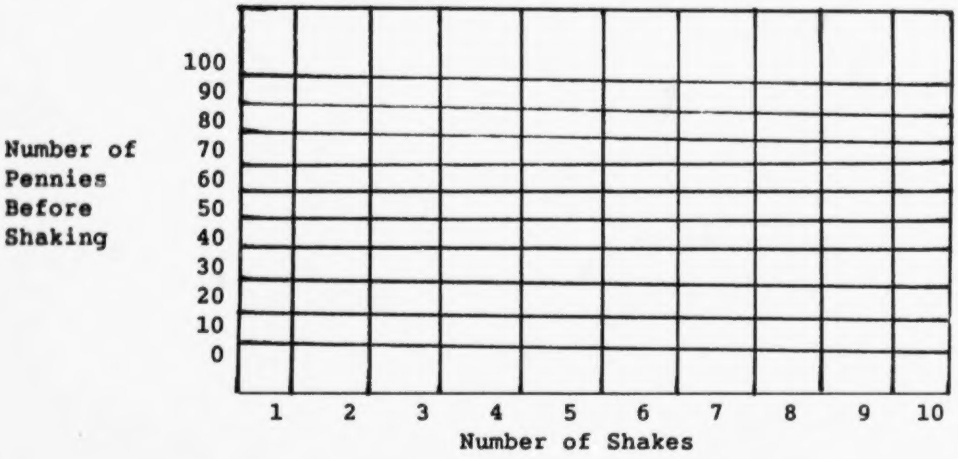
DATA CHARTS:

PENNIES

Shake Number	Number of Pennies Before Shaking	Number of Pennies Decayed (Flipped Over)	Percent* That Decayed
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

$$* \ \% \text{ Decayed} = \frac{\text{number that decayed}}{\text{number before shaking}} \times 100$$

Graph



UNIT II
Lesson D3

STUDENT LABORATORY WORKSHEET
(page 3 of 3)

NAME ______________________________ **CLASS** ______ **DATE** ______ **LAB GROUP #** ______

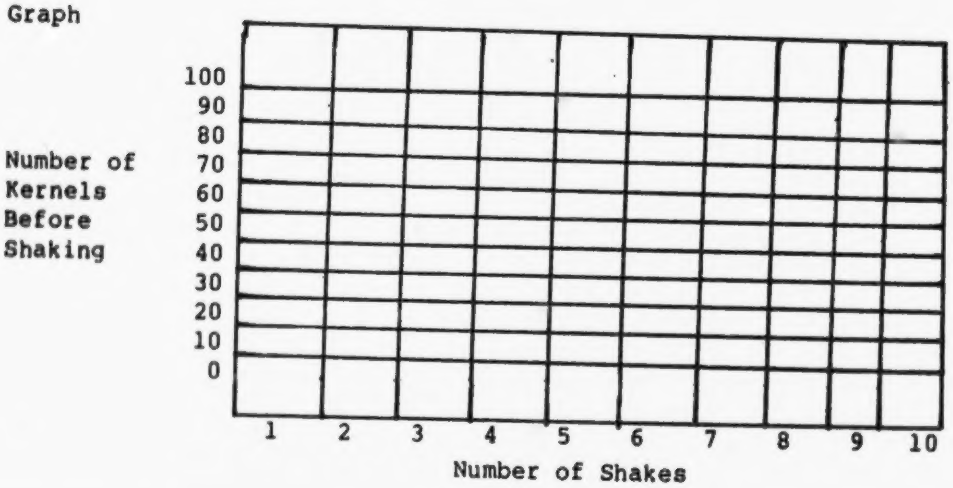
DATA CHARTS:

CORN KERNELS

Shake Number	Number of Corn Kernels Before Shaking	Number of Corn Kernels Decayed (Pointed to X end)	Percent* That Decayed
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

$$* \text{ Percent Decayed} = \frac{\text{number that decayed}}{\text{number before shaking}} \times 100$$

Graph



LESSON D4

TOPIC: Fossils (part 1)

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D8

PROCESS SKILLS: 1, 2, 5, 17, 20

AIM: What is a fossil?

MATERIALS:

- fine sand
- hose with fine jet
- shells or bones
- chicken bone
- clay
- 3 cellulose sponges (approximately 3cm x 3cm x 10cm)
- plaster of Paris
- metric ruler
- 2 small Pyrex beakers
- 250mL beaker
- paraffin
- nitric acid
- petrified wood
- photos, illustrations, etc., of various extinct forms of life

PERFORMANCE OBJECTIVES: Students will be able to:

- define the term fossil.
- explain how fossils are formed and preserved.
- distinguish between a mold and a cast.
- judge whether an object is or is not a fossil.

MOTIVATION:

- Show the class pictures of saber-toothed tigers, dinosaurs, trilobites, etc., and ask students to explain how we are able to obtain pictures of living things from the geologic past.

PROBLEM: Objects have been found on earth that give clues to life in the past. How did these objects form? How were they preserved?

AIM: What is a fossil?

DEVELOPMENTAL STRATEGIES:

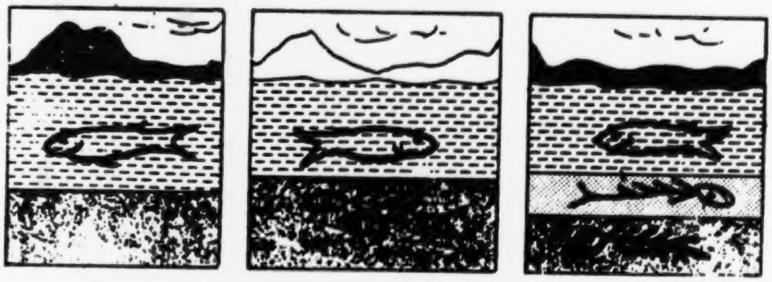
- Show the class the following objects: igneous rock; chicken bone; fossil shell, bone, or tooth; fossil imprint. Ask the students which objects are fossils. Write the definition of fossil on the board.

- Ask the class to give examples of how fossils can be formed. Examples of fossils include: hard parts (bone, shell, teeth); molds (footprint, leaf print, shell print); casts (molds that have been filled in); petrified wood, bone, or shell; frozen (encased in ice).

- Demonstrate one or more of the following:

  - Ask how fossils are formed in shallow seas. Demonstration: In a box of fine sand make a shallow depression and drop a bone, shell, or other object into the depression. Then direct a fine stream of water onto the sand that surrounds the hole. Guide the students to see how the sand covers the object. Elicit that the object must be a hard substance; otherwise, it would decay before it had a chance to be covered.

  - With the aid of a diagram like the illustration below explain how fossils are formed in sedimentary rocks.



  - Ask students the names of the various types of sedimentary rocks. Tell them that the fossils found in shale are much easier to recognize than those found in sandstone. Elicit that very fine sediment is ideal for producing fossils. Display a fern fossil in shale.

  - Distribute enough clay to each student to fill the cover of a large jar. Have the students flatten the clay on a piece of toweling. Then hand out shells or other hard objects. Have students press the objects into the clay and then remove the objects. Pour plaster of Paris, of a creamy consistency, into each mold. Elicit that the clay represents the ocean bottom and the shell an ancient animal which has just died and fallen to the bottom. The plaster of Paris represents minerals dissolved in seawater replacing the shell. Put plaster of Paris fossils away for a later lesson.

ADVANCE PREPARATION:

Several days beforehand, prepare for a demonstration of the petrification process as follows:

- Melt paraffin in a Pyrex beaker and soak two cellulose sponges in melted paraffin.

- When paraffin has hardened, dissolve one of the sponges in concentrated nitric acid in another beaker (make small holes to hasten penetration of the acid). The paraffin will remain. **Caution: Nitric acid is corrosive; use extreme care.**

- After the cellulose has dissolved--3 to 4 days--discard the acid and rinse sponge thoroughly with water.

- Pour thin plaster of Paris into the paraffin sponge and let it harden. (The plaster should replace the original material of the sponge.)

- Heat the paraffin-plaster "sponge" at a very low temperature to melt and remove the paraffin. The plaster specimen should resemble the original sponge.

  - Display an untreated cellulose sponge and the plaster sponges. Ask the students to hold each sponge and describe it. Elicit that even though all look alike, two are harder than the orignal, which is of a different material. Explain how you made the two sponges. Point out that some porous shells and bones become fossils by permineralization, that is, by being filled with minerals (e.g., the sponge impregnated with paraffin), while others are formed by replacement of the original components (e.g., the plaster sponge). Pass around some petrified wood and point out that it was formed by replacement.

SUMMARY:

- Fossils are the remains or evidence of animals and plants that lived in the geologic past.

- Fossils are found almost exclusively in sedimentary rocks.

- An organism usually must contain hard parts and be buried immediately in order to become a fossil.

- Fossils may be formed by processes such as petrification (replacement) and permineralization.

- Fossils are often found in the form of impressions (footprints, leaf prints, shell prints).

- Molds show the shape of the original organism imprinted on rocks.

- Casts are formed by minerals which fill the molds.

HOMEWORK:

- Why are fossils found mainly in sedimentary rock?

- If you were to bury a dead bird, would it become a fossil? Explain.

- Why is the sea such a good place for fossil formation?

- Explain how a tree originally composed of wood can become completely petrified.

- Classify the following materials as fossils or nonfossils. Explain your method of classification.
  - one-billion-year-old igneous rock
  - chicken bones from last night's dinner
  - dinosaur footprint
  - 200-million-year-old clamshell

ENRICHMENT:

- Report on a specific type of fossil formation, e.g., petrification, casts and molds, frozen remains.

- Report on where and what type of fossils can be located in the New York metropolitan area.

- Report on the reasons why fossils are not usually found in New York City.

LESSON D5

TOPIC: Fossils (part 2)

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D8/D57, 59, 60

PROCESS SKILLS: 1, 2

AIM: What is a fossil?

MATERIALS:

- tar or tarry fluid
- string
- branch of pine tree
- shellac or clear nail polish
- several actual fossils, or models of them
- pictures of saber-toothed tigers, mammoths, mastodons, giant ground sloths, etc.

PERFORMANCE OBJECTIVES: Students will be able to:

- explain several ways in which fossils may form.
- show how a fossil may be a key to the prehistoric environment of an area.
- summarize the conditions needed for fossil formation.

MOTIVATION:

- Tell the students that a group of explorers found and ate meat from an animal that had been dead for over 11,000 years. Elicit how this might be possible.

PROBLEM: What evidence is there that life existed on the earth millions of years ago?

AIM: What is a fossil?

DEVELOPMENTAL STRATEGIES:

- Explain the motivation. Several wooly mammoths have been found perfectly preserved in glaciers. Show pictures or discuss these stories. One find in the early 1900s had a yellowish skin under long brown hair. Preserved inside its stomach were 27 pounds of chewed, but not yet digested, pine cones, wildflowers, grass, herbs, and moss. Some of the seeds were so well preserved that when planted 11,000 years later, they grew. Elicit that freezing preserves flesh, and compare this to modern frozen foods.

- Demonstrate how animals were caught in tar pits. Prepare a very thick, sticky fluid (tar, tree wound paint, molasses). Tie a string onto a piece of chalk and place the chalk on the fluid. Be sure students see the chalk sink into the fluid. Point out that many such tar pits can be found in nature (for example, in LaBrea, California). Elicit that animals might wander into a tar pool covered with water, be caught and sink into it. Other animals, attracted by the dying animals, also sink into the tar. Show pictures of saber-toothed tigers, camels, mammoths, mastodons, giant ground sloths, bison, bears, and dire wolves. Tell students that remains of all these animals have been removed from the Los Angeles tar pits.

- Demonstrate how insects and flowers become trapped in resin. Elicit that a very sticky resin will flow from a pine tree. If possible, have students examine the sticky resin of a freshly cut pine branch. Place some shellac or clear nail polish on a piece of cardboard, and drop a small object such as a flower or piece of string into the shellac. Elicit that a small insect could be trapped in the resin after landing on a tree. Show the students insect specimens preserved in plastic (or in amber, if possible). Have students examine a piece of amber, which is hardened resin. Define fossils as the remains or evidence of animals and plants that once lived on the earth.

  - If an animal were to fall dead in a forest, what would be its chances of becoming a fossil? (Elicit that the chances of being preserved are very poor because the animal might be eaten by other animals or its body might decay. Guide the students to see that fossils or original remains are very rare. Elicit the conditions necessary for fossil formation. They include rapid burial in fine-grained material and the exclusion of oxygen.

- Show students pictures of a developmental series of fossils, such as a picture of horse skeletons through the Cenozoic. Point out that fossil finds have helped scientists trace the evolution of plants and animals.

- Discuss the significance of fossil finds such as ferns in Alaska, or corals in New York State. Have the students understand that fossils often give us clues to what the environment was like in an area millions of years ago.

SUMMARY:

- Fossils are the remains or evidence of animals and plants that lived on the earth millions of years ago.

- Most organisms leave no fossil remains because they decay or are eaten.

- Flesh and other soft tissues of plants and animals have been preserved in tar pits, ice, and amber.

- Fossils show us that species of organisms change as time progresses.

- Fossils can indicate past climates and environments.

HOMEWORK:

- What is a fossil?
- List several ways in which fossils have been formed.
- Explain why it is rare to find the original remains of an organism.
- Explain at least two ways our foods are preserved that are analogous to fossil formation.

ENRICHMENT:

- Go to the library and look at pictures of prehistoric animals and their modern-day counterparts. Explain how the animal changed through time. Horses, tigers, elephants, and humans are good examples.
- Find out other ways in which fossils can be preserved. How, for example, do we get petrified wood, or footprints, or molds and casts of specimens?
- Report on a specific type of fossil formation, e.g., petrification, casts and molds, frozen remains.
- Report on where and what type of fossils can be located in the New York metropolitan area.
- Report on the reasons why fossils are not usually found in New York City.

UNIT II

LESSON D6

TOPIC: Fossils fuels

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D

PROCESS SKILLS: 1, 2, 14, 17

AIM: Why are petroleum, coal, and natural gas called fossil fuels?

MATERIALS:

- ring stand
- clamp
- large test tube
- one-holed rubber stopper
- glass tubing
- burner
- plant material (twigs, pine needles, leaves)
- samples of peat, lignite, bituminous coal, and anthracite coal (or filmstrips, transparencies, or photos illustrating these materials)
- drawing or transparency showing the formation of oil and natural gas

PERFORMANCE OBJECTIVES: Students will be able to:

- define the term fossil fuel.
- explain the formation of coal, petroleum, and natural gas.

MOTIVATION:

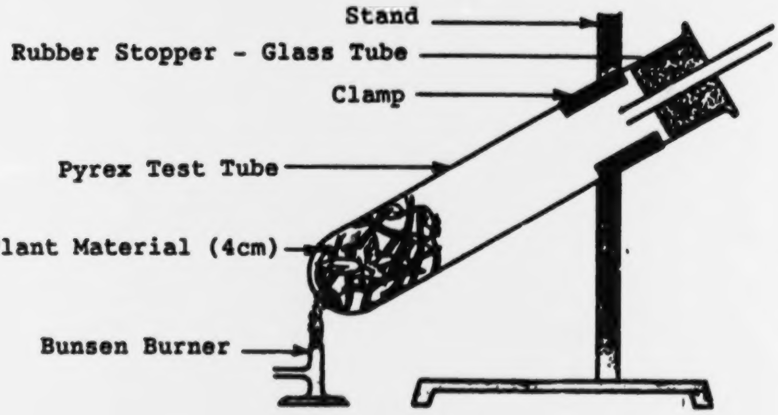
- Fuel is a material that produces heat or power when it is burned. We have examined samples of fossils. Would you consider any of these fossils fuels? (Elicit examples of various fuels: coal, oil [petroleum], natural gas, wood, etc.) Ask the class why wood cannot be considered a fossil.

PROBLEM: Petroleum, coal, and natural gas are examples of fuels. They are also fossils. How is this possible?

AIM: Why are petroleum, coal, and natural gas called fossil fuels?

DEVELOPMENTAL STRATEGIES:

- Tell students that petroleum and coal are called fossil fuels. To demonstrate that plant material can be broken into the element carbon and other compounds, place some plants, twigs, leaves, pine needles, etc., into a test tube which has a tightly fitted stopper and a glass tube inserted in it (see diagram on next page).



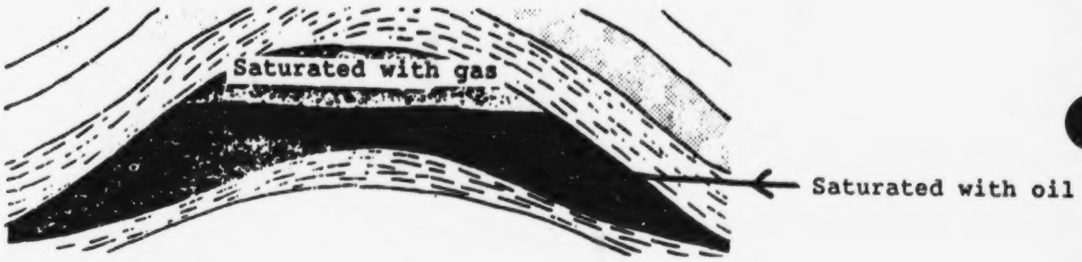
- Heat the test tube for a few minutes until smoke begins to come out of the glass tube. Try to ignite this gas with a lighted splint. (If the splint goes out--water vapor coming out of the tube tends to extinguish the flame--relight it.) Keep heating the tube, being sure students observe that the plant material inside the test tube turns black. Elicit that the black residue in the test tube is charcoal. Point out that charcoal is a form of carbon, and so is coal.

- Ask, "How do you think coal can be formed naturally?" Distribute samples of peat, lignite, bituminous coal, and anthracite coal. Guide students to see that peat and lignite are composed of loose pieces of plant material. Elicit that these specimens are composed of sediments of plant material. Point out that peat and lignite represent early stages of coal formation and that they formed millions of years ago as plant material died and began to form sediments in marshes and swamps.

- Have students compare bituminous and anthracite coal. Elicit that the antracite is harder and denser. Then ask, "What type of rock is bituminous coal?" Have students conclude that anthracite coal is a metamorphic rock and that it was changed from sedimentary bituminous coal by heat and pressure over a long period of time.

- Discuss how scientists believe that crude oil was formed in ancient swamps or seas when marine plants and animals were covered with sediment. Chemical and physical changes produced oil from the bodies of these marine organisms.

- Using the conclusions of the demonstration in which plants, twigs, and leaves were heated, elicit that if heat and pressure are added to fossil fuels, natural gas will form. Natural gas may also be produced by the decaying action of bacteria on plant and animal materials.



With the above illustration, point out that natural gas and oil are usually discovered together.

SUMMARY:

- A fossil fuel is a material used for heat and power that originally was a plant or animal.
- Coal is the end product of a metamorphic process in which prehistoric plants are changed from peat to lignite, then to bituminous coal, then to anthracite coal.
- Petroleum and natural gas come from the decay of tiny marine animals and plants.

HOMEWORK:

- "When we burn coal we are really using the sun's energy." Explain this statement.
- How did coal and oil get so deep into the earth?
- Why would oil companies hire geologists and paleontologists to help find oil deposits?

ENRICHMENT:

- Describe the ancient climates of the areas where the following are found:
  - marine fossils in Texas
  - coral fossils in Maine
  - coal deposits in Pennsylvania
  - salt deposits in New York State
- List some areas where the formation of coal may be beginning.
- Explain why fossil fuels are considered to be nonrenewable resources.

LESSON D7

TOPIC: The geological record

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D/D8

PROCESS SKILLS: 3, 5, 9, 13, 14

AIM: What does the rock record suggest about geologic history?

MATERIALS:

Per lab group:
- Reference Sheet
- graph paper and/or cash register tape
- scissors
- tape
- crayons
- meterstick

PERFORMANCE OBJECTIVES: Students will be able to:

- identify the age of the earth to be about 5 billion years.
- list the geologic eras that comprise the earth's history.
- identify the major forms of life and geologic activity in each era.
- compare and contrast the life and geologic activity in each era.
- analyze the significance of time in the earth's history.

MOTIVATION:

- Most of the fossils we have examined and talked about indicated that the earth has a long history. The fossil record and information about mountain building, sedimentation, uplift, and erosion are all illustrated on the accompanying Reference Sheet, "Geologic Time Scale."

PROBLEM: How can we organize the information from the Geologic Time Scale table so that it vividly illustrates the immense amount of time in the earth's history?

AIM: What does the rock record suggest about geologic history?

DEVELOPMENTAL STRATEGIES:

- Distribute copies of the Reference Sheet. Using the information it presents, construct a geologic time line. Each laboratory group, working as a team, should solve the problem. Each group should form a hypothesis of how to solve the problem and present the plan for the teacher's approval before starting work.

- Encourage the groups to be creative and artistic. (Some groups may wish to use graph paper; other groups may want to work with cash register tape.)

SUMMARY:

- The planet earth is approximately 5 billion years old.
- The history of the earth can be divided into the following long divisions of time called eras: Precambrian, Paleozoic, Mesozoic, Cenozoic.
- The Precambrian represents the formation of the earth and the beginnings of life. Fossil records are poor.
- The Paleozoic has a good fossil record including evidence of fish, amphibians, reptiles, and various other forms of animal and plant life.
- The Mesozoic is known as the age of reptiles (dinosaurs).
- The Cenozoic is known as the age of mammals.
- The Cenozoic, Mesozoic, and Paleozoic eras are divided into smaller units of time called periods.

HOMEWORK:

- For what percentage of time has there been evidence of life on earth?
- Movies show humans fighting dinosaurs. Explain why this could not be true.
- How can a trilobite be used to pinpoint the age of a certain rock?
- Explain why you may (or may not) have had difficulty in placing information on your group's time line.
- How does the period of human existence compare with the earth's history?

ENRICHMENT:

- Report on a particular era or period in earth's history.
- Report on the description of New York City or New York State during a particular era, period, or epoch in the earth's history.
- Report on current theories of why the dinosaurs became extinct at the close of the Mesozoic.
- Report on environmental factors that may cause the extinction of mankind.

PROBLEM:

How can we construct a time line representing the history of the earth?

HYPOTHESIS:

- Using information from the Geologic Time Scale, construct a time line on graph paper with a scale of 1cm equal to 10 million years. It would require 500cm (boxes) to represent the age of the earth (5 billion years).

MATERIALS: graph paper or cash register tape, scissors, tape, crayons, Reference Sheet

PROCEDURE:

1. Cut each piece of graph paper into equal-sized strips or, using a meterstick, cut a piece of cash register tape to the desired length needed to represent the history of the earth.

2. Tape the strips end to end, forming a long strip 500 boxes long (or use a piece of cash register tape 500cm long).

3. Draw a line down the center of the strip to represent geologic time.

4. Mark one end 0 years. Mark the beginning and end of each era and period. Use different colors to represent the eras and periods.

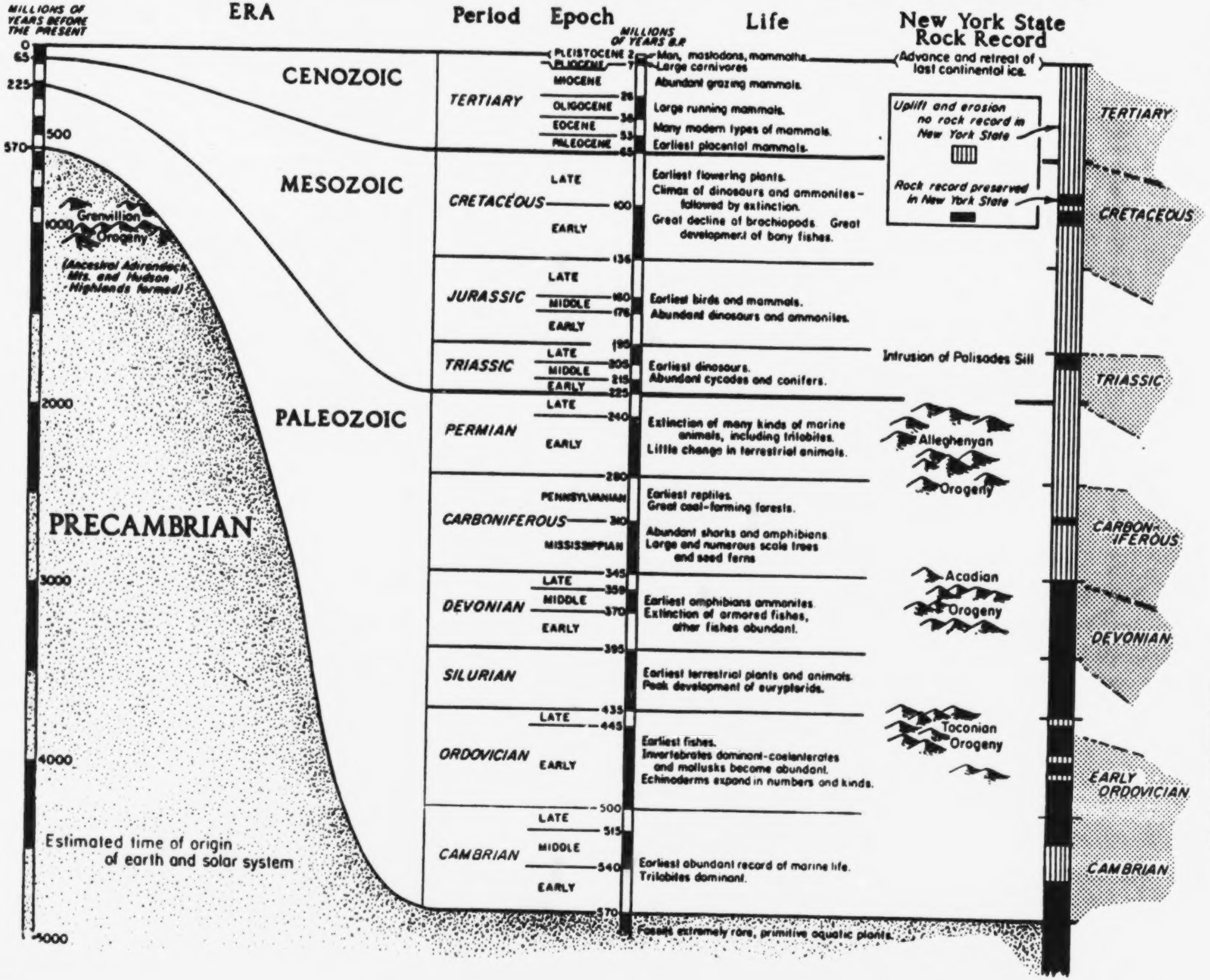
5. On one side of the time scale, label the eras and periods.

6. On the other side of the line, record the life forms and major events that occurred during each era and period. Draw diagrams directly on the time line illustrating the event.

CONCLUSION:

The history of the planet earth can be represented on a line 500cm long, if each centimeter represents 10 million years of time. Other scales can be used, e.g., a 5000cm line if each centimeter represented 1 million years of time, a 1000cm line if each centimeter represented 5 million years of time.

Geologic time scale, showing major events in geological history


MILLIONS OF YEARS BEFORE THE PRESENT
ERA
Period
Epoch
MILLIONS OF YEARS B.P.
Life
New York State Rock Record
0
65
225
570
500
1000
2000
3000
4000
5000
CENOZOIC
MESOZOIC
PALEOZOIC
PRECAMBRIAN
Grenvillion Orogeny
(Ancestral Adirondack Mts. and Hudson Highlands formed)
Estimated time of origin of earth and solar system
TERTIARY
PLEISTOCENE 2
PLIOCENE 7
MIOCENE
26
OLIGOCENE
38
EOCENE
53
PALEOCENE
65
CRETACEOUS
LATE
100
EARLY
136
JURASSIC
LATE
160
MIDDLE
176
EARLY
190
TRIASSIC
LATE
205
MIDDLE
215
EARLY
225
PERMIAN
LATE
240
EARLY
280
CARBONIFEROUS
PENNSYLVANIAN
310
MISSISSIPPIAN
345
DEVONIAN
LATE
359
MIDDLE
370
EARLY
395
SILURIAN
435
ORDOVICIAN
LATE
445
EARLY
500
CAMBRIAN
LATE
515
MIDDLE
540
EARLY
570
Man, mastodons, mammoths.
Large carnivores
Abundant grazing mammals.
Large running mammals.
Many modern types of mammals.
Earliest placental mammals.
Earliest flowering plants.
Climax of dinosaurs and ammonites—followed by extinction.
Great decline of brachiopods. Great development of bony fishes.
Earliest birds and mammals.
Abundant dinosaurs and ammonites.
Earliest dinosaurs.
Abundant cycades and conifers.
Extinction of many kinds of marine animals, including trilobites.
Little change in terrestrial animals.
Earliest reptiles.
Great coal-forming forests.
Abundant sharks and amphibians.
Large and numerous scale trees and seed ferns
Earliest amphibians ammonites.
Extinction of armored fishes, other fishes abundant.
Earliest terrestrial plants and animals.
Peak development of eurypterids.
Earliest fishes.
Invertebrates dominant-coelenterates and mollusks become abundant.
Echinoderms expand in numbers and kinds.
Earliest abundant record of marine life.
Trilobites dominant.
Fossils extremely rare, primitive aquatic plants.
Advance and retreat of last continental ice.
Uplift and erosion no rock record in New York State
Rock record preserved in New York State
Intrusion of Palisades Sill
Alleghenyan Orogeny
Acadian Orogeny
Toconian Orogeny
TERTIARY
CRETACEOUS
TRIASSIC
CARBONIFEROUS
DEVONIAN
EARLY ORDOVICIAN
CAMBRIAN

LESSON E1

TOPIC: Continental drift

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D7

PROCESS SKILLS: 1, 2, 13

AIM: What is the continental drift theory?

MATERIALS:

- transparency of Teacher Reference Sheet, "200 Million Years of Continental Drift"
- map of the earth showing surface features
- jigsaw puzzle maps of the earth (Student Handout)
- 2 large damp sponges

PERFORMANCE OBJECTIVES: Students will be able to:

- define the theory of continental drift.
- explain how convection cells within the mantle relate to crustal motion.
- compare continental positions from 200 million years ago to the present.
- infer that crustal motion helps to explain many landscape features and present continent positions.

MOTIVATION:

- Display a map of the world (preferably one that clearly shows surface features). Ask the class if the continents look as though they could be cut out and placed together like a jigsaw puzzle.

PROBLEM: How could these continents be thousands of miles apart but apparently fit together?

AIM: What is the continental drift theory?

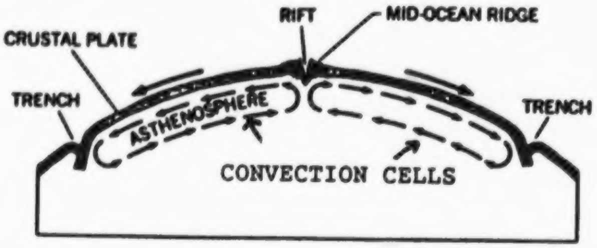
DEVELOPMENTAL STRATEGIES:

- Point out that all the continents were once joined together in a giant land mass that later separated. This is known as the theory of continental drift. Display the transparency "200 Million Years of Continental Drift."

- Ask students what evidence there is that the continents were once one land mass. Elicit that the rock layers correlate on opposite sides of the oceans. This has provided evidence for continental drift.

- The current continental drift theory states that, since the solid oceanic crust is denser than the much hotter liquid (magma), when the oceanic crust plunges under the edges of the continents at the subduction zones, it exerts gravitational forces that pull the plates apart, leaving gaps through which magma upwells.

- Draw the following diagram on the chalkboard:



- Pose the following question: "Can you explain why the earth's crust has been split into large separate sections?" Elicit that as the ocean floor crust moves downward under the edges of the continents, gravitational forces pull the plates apart.

- Ask the class which landscape features on the earth's crust can be explained by crustal plate collisions, e.g., Alps, Andes, Appalachians. Explain that movement and interaction over millions of years helps to explain folding, faulting, earthquakes, mountains, volcanoes, and many other landscape features on the continents and the sea floor. Demonstrate by pushing on both ends of a sheet of paper to show folding. Push two large damp sponges together and have one override the other to show faulting, earthquakes, and mountain building.

- Reinforce the idea that scientists still do not have the answer to the question of what forces move the crust. Explain that the answer may lie in the forces both beneath the crust and at its surface.

SUMMARY:

- The theory of continental drift states that the continents were once joined together in a giant land mass that has separated. They are still moving today.

- By correlating rocks from opposite sides of the oceans, scientists have derived evidence for continental drift.

- As the ocean crust moves downward under the edges of the continents, gravitational forces pull the plates apart.

- Folding, faulting, earthquakes, mountains, volcanoes, and other surface features can be explained by crustal plate motion.

- Crustal plates can be placed together - like a jigsaw puzzle - to form a giant landmass.

HOMEWORK:

- Explain the driving force behind the movement of the crustal plates.

- Describe the evidence used to prove that the continents were once together.

- Distribute jigsaw puzzle maps of the world. Have students asssemble a model of the seven major plates and identify each by name: African, Antartic, Australian-Indian, North American, Pacific, South American, Eurasian.

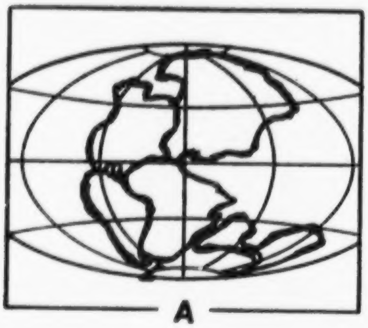
  - What could happen when two plates collide?

ENRICHMENT:

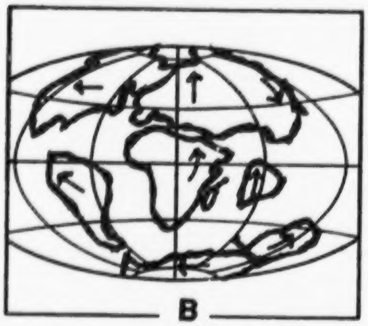
- Report on the history of the continental drift theory. (Include Alfred Wegener.)

- Speculate on where the continents will be in the future.

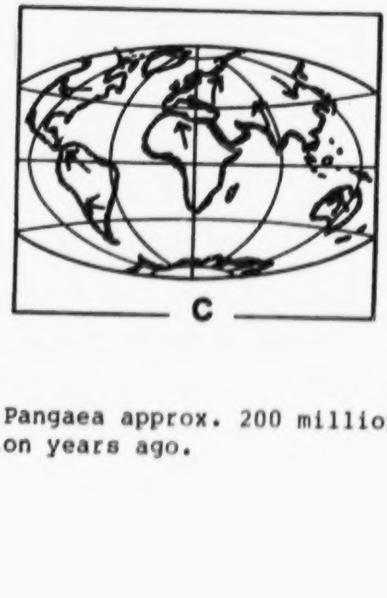
200 Million Years of Continental Drift



A



B



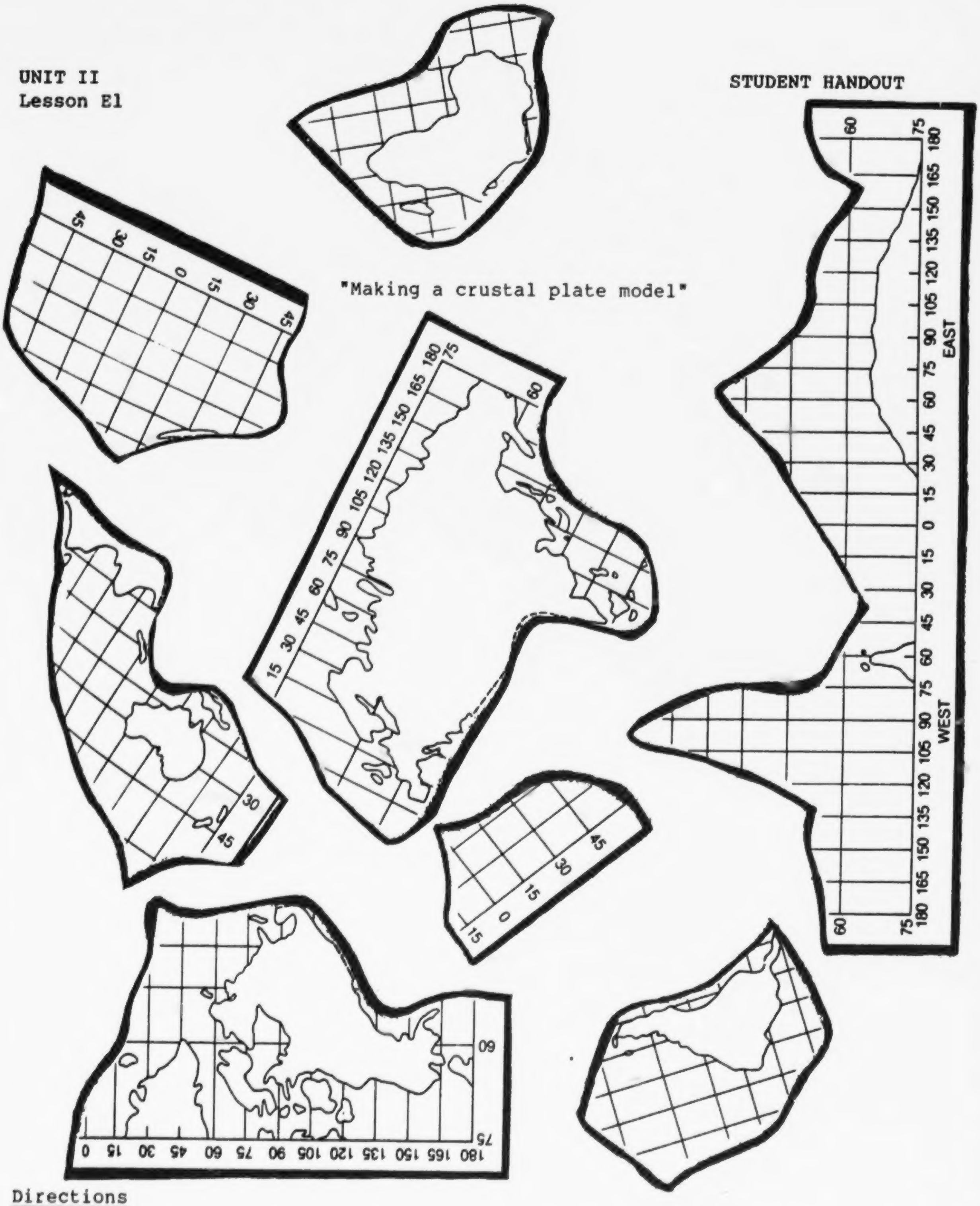
C

a) The supercontinent of Pangaea approx. 200 million years ago.
b) The continent 65 million years ago.
c) The continents today.

UNIT II
Lesson E1

STUDENT HANDOUT

"Making a crustal plate model"


45
30
15
0
15
30
45
30
45
15
30
45
60
75
90
105
120
135
150
165
180
75
60
45
30
15
0
15
60
75
180
165
150
135
120
105
90
75
60
45
30
15
0
15
30
45
60
75
90
105
120
135
150
165
180
EAST
WEST
60
75
60
75
180
165
150
135
120
105
90
75
60
45
30
15
0

Directions

1. Cut out each piece and put them together like a jigsaw puzzle to form a model of the major plates.

2. Label the seven plates on your map.

Holt Earth Science. Holt, Rinehart, Winston, 1986. Permission Pending.

LESSON E2

TOPIC: Mountain formation

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D/D1, D7

PROCESS SKILLS: 1, 2, 9

AIM: What forces build up the earth's crust?

MATERIALS:

- clays of different colors
- 30cm X 46cm colored construction paper (full package)
- beaker
- water
- heat source
- potassium permanganate
- pictures of mountains
- Encylopedia Britannica film, Why Do We Still Have Mountains? (optional)

PERFORMANCE OBJECTIVES: Students will be able to:

- deduce that fossils of marine organisms on mountaintops serve as evidence of crustal growth.
- demonstrate how pressure, heat, and movements of the earth's crust form mountains.
- analyze how earth movements can cause the crust to fold.
- explain that the gravitational forces that pull the ocean floor crust under the edges of the continents (at the subduction zones) also pull the crustal plates apart.
- explain how volcanic activity has formed or extended mountains and/or islands.

MOTIVATION:

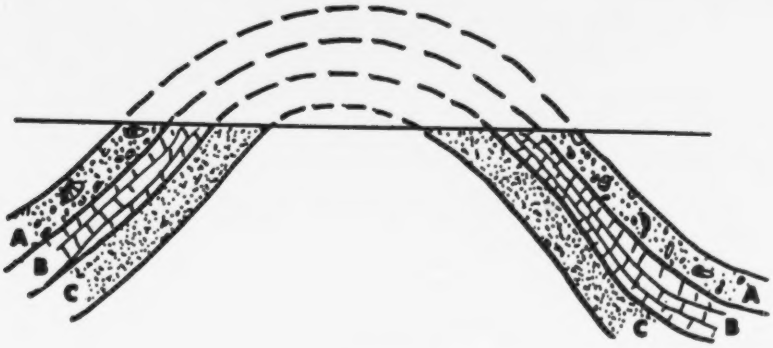
- Tell the students that remains of marine animals have been found at an elevation of more than 20,000 feet in the Himalayan Mountains. Marine organisms have also been found near New York City in the Catskill Mountains. Ask the class to formulate a hypothesis to explain how this could have occurred.

PROBLEM: How do the fossils of marine animals high up on mountains show evidence of a change in the earth's crust?

AIM: What forces build up the earth's crust?

DEVELOPMENTAL STRATEGIES:

- Allow the students to speculate that an ocean may have covered the top of these mountains or that the land may have moved upward over a long period of time. Tell the class that additional evidence will be useful in solving this problem. Draw a diagram of tilted strata on the chalkboard:



Point out that sediments are usually laid down in horizontal layers. Tell the class that we find layers that are tilted. Connect the strata to show that there existed a mountain which had been eroded. Ask: "If animal remains existed in layer A, where would they have been found in the remains of that mountain?" Have the class conclude that animal remains found on the tops of mountains could have gotten there only by the upward movement of the earth's crust.

- Refer to the diagram of the tilted strata and ask, "How do you think the layers became tilted?" Take a package of 20cm X 46cm colored construction paper. Ask, "What do the various layers of colors represent?" Push the ends of the package together. Have the students compare their observations with the diagram. Show pictures of regions with folded rocks. Define the terms anticline and syncline (upfold and downfold).

- Using layers of clay of various colors, show that as you exert a force on a plastic material it will bend and fold. Elicit that the mantle of the earth has a plastic consistency and that heat and pressure from the earth's interior cause the crust to fold.

- Use the following demonstration to show convection currents. Drop a crystal of potassium permanganate into a beaker of water. Heat the beaker gently and have the class note the movement of the colored material within the solution. Elicit that the heat of the earth can set up convection currents, and mountains may form if the earth's crust is pushed together due to pressure created by convection currents.

- Ask the class to describe the Hawaiian Islands. Elicit that they are volcanic islands produced by molten material which flowed through the sea floor and gradually rose up and out of the floor. A new island is expected to be above sea level in about 10,000 years. Explain that volcanic activity can also extend mountain ranges. The Adirondack Mountains are domed mountains formed by an igneous intrusion that pushed up the overlying strata.

- Distribute copies of the Reference Sheet (or make it into a transparency) and discuss the following information with students:

  - As an ocean plate descends along a fault in a subduction zone, friction produces enough heat to melt the rock of the plate. While the denser part of the melt becomes part of the mantle, the less dense portions may float upward through the crust to form volcanic mountains, such as the Andes Mountains of South America.

SUMMARY:

- Lateral pressures from crustal movements cause folding of rock into upfolds (anticlines) and downfolds (synclines). Under pressure, a fracture may develop along which bedrock is displaced.

- Mountains, with their sharply folded and broken rock, indicate that strong forces have acted in the past.

- Horizontal layering is characteristic of sedimentary rock. Folded, tilted, or fractured sedimentary rock is evidence that forces have acted on the rock.

- Mountains and islands have been formed or extended as a result of volcanic activity.

HOMEWORK:

- What are some evidences from the past that parts of the earth's crust have been raised?

- What are some of the major sources that cause the earth's crust to form mountains?

- Explain how convection currents are developed within the earth.

ENRICHMENT:

- Why hasn't erosion worn down the continents so that all of the land is level?

- How do the following prove that the land rose?

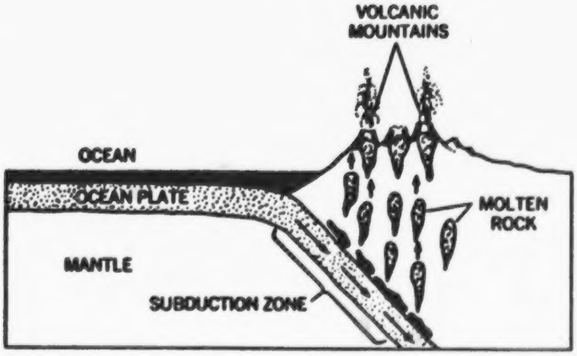
  - marine shells on beaches hundreds of feet above the coastline
  - a sea cave on top of another sea cave
  - sedimentary rock on top of mountains

- Draw a diagram of a folded rock region.

- Explain the following statement:

  Most of New York State is in the Appalachian Plateau. The Catskills are not mountains since the rock strata are mainly horizontal.

How Plate Movements Produce Volcanic Mountains


VOLCANIC MOUNTAINS
OCEAN
OCEAN PLATE
MOLTEN ROCK
MANTLE
SUBDUCTION ZONE

From Horowitz, Contemporary Earth Science. (Amsco School Publications, 1976). Permission pending.

LESSON E3

TOPIC: Volcanoes

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D/D1, D7

PROCESS SKILL: 9

AIM: How has volcanism changed the earth's surface?

MATERIALS:

- pictures or slides of volcano types
- metal cup or crucible
- ammonium dichromate
- 5cm magnesium ribbon
- bunsen burner
- ammonium chloride
- sample of obsidian, pumice, gabbro, basalt
- Student Reference Sheet

PERFORMANCE OBJECTIVES: Students will be able to:

- explain that volcanoes or lava flows result when pressure inside the earth pushes magma toward the surface.
- distinguish among a quiet volcano that flows, a violent eruption, and a combination of both.
- give an example of how volcanoes build up the land.
- explain that molten rock which does not reach the earth's surface will push the surface upward to squeeze itself between rock layers.

MOTIVATION:

- Place some granular ammonium dichromate into a metal cup or small crucible. (Add a few sprinkles of ammonium chloride to make smoke.) Insert a 5cm magnesium ribbon into the chemicals. Light the "fuse" of magnesium ribbon with a bunsen flame or a match until it burns vigorously. Ask students to explain the purpose of this demonstration, and to describe their observations.

CAUTION: Move students away from the demonstration. Warn them not to look directly at the burning magnesium ribbon. Refer to Board of Education Safety Manual, page 14 for precautions when using ammonium dichromate and magnesium together. These safety precautions are essential!

PROBLEM: How do volcanoes affect the earth?

AIM: How has volcanism changed the earth's surface?

DEVELOPMENTAL STRATEGIES:

- Have students note the steep cone that is built up with the ashes. Elicit that molten material coming from a volcano will build up the surrounding area. Tell them that it is called a cinder cone.

- Point out that in order to make a volcano a chemical was placed in the center. Ask, "Where does molten material come from in a real volcano?" Have students recall that as you go deeper into the earth, the pressure and temperature increase. Elicit that this pressure pushes the magma toward the surface.

- Display pieces of obsidian and pumice. Tell the class that both of these rocks came from molten magma. Elicit that obsidian is formed inside the earth whereas pumice is formed outside. Ask, "How do you account for the fact that some rocks are formed under the surface of the earth while others are formed outside?" Point out that some magma is forced through weak spots in the earth's surface, causing volcanic eruptions.

- Elicit that the opening in the earth's crust through which the lava flows is called the chimney of a volcano. Show pictures or slides of the various types of volcanoes. Point out that Mt. Katmai in Alaska is an explosive volcano with a steep cinder cone, whereas Mauna Loa in Hawaii is a quiet volcano with a gentle lava slope. Tell students that most volcanoes are both gentle and explosive. Mention to the students some famous volcanic eruptions that have taken place on the earth.

- Distribute copies of Student Reference Sheet (or display it as a transparency) and discuss the formation of intrusive volcanism.

- Point out that there are enormous storehouses of magma located in the earth's crust. If this magma does not reach the surface, different types of underground formations results. (Examples of these are sills, dikes, laccoliths, batholiths, and domed mountains.)

- Ask students where volcanic material occurs near New York City. Tell them that the Palisades of the Hudson River are an example of a sill that has been exposed by erosion.

SUMMARY:

- Volcanism is the movement of molten rock at or near the earth's surface.

- Hot liquid rock beneath the earth's surface or generated within the crust is called magma; lava is magma on the earth's surface.

- In certain localities, molten rock and gases reach the surface in the form of volcanic eruptions and fissure flows. Although lava flows are destructive, the lava weathers rapidly to form very fertile soil.

- The ultimate cause of volcanism, the process by which magma is generated, is unknown, but it is generally thought to be the heat released by radioactive decay.

- Igneous intrusions are the result of volcanic activity that does not reach the earth's surface.
- Most magmas never reach the surface, but solidify to form igneous rocks underground.

HOMEWORK:

- What happens to lava when it cools?
- What is the difference between a quiet volcano and an explosive one?
- How were the Hawaiian Islands formed?
- Draw a diagram of an area of volcanic activity. Include all features that might be found within the crust as well as those found on the surface.
- Define the following:
    - batholith
    - laccolith
    - volcanic core
    - sill
    - dike
    - crater
    - domed mountain
    - lava flow
    - neck

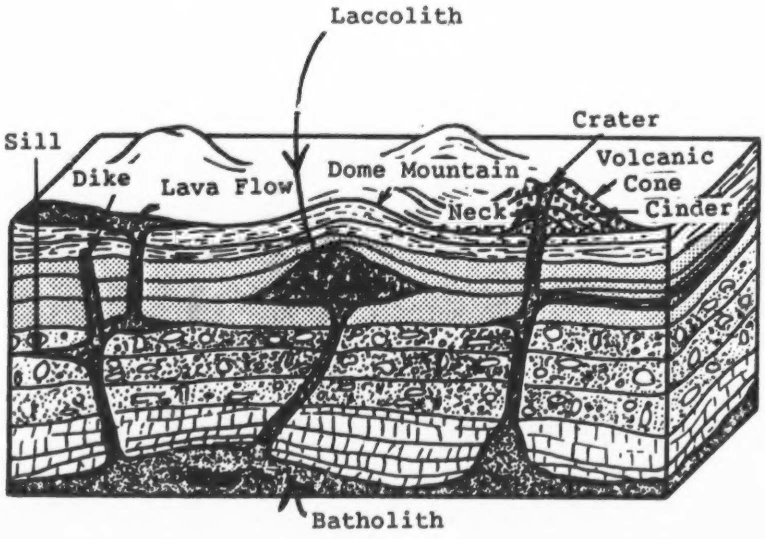
ENRICHMENT:

- How do volcanoes build up the land?
- Where does the lava come from?
- What makes the lava come out of the ground?
- Describe the three types of volcanoes and give an example of each.

UNIT II
Lesson E3

REFERENCE SHEET

Intrusive Volcanism


Laccolith
Sill
Dike
Lava Flow
Dome Mountain
Crater
Volcanic Cone
Neck
Cinder
Batholith

UNIT II

LESSON E4

TOPIC: Earthquakes

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D/D1, D7

PROCESS SKILLS: 1, 2, 9

AIM: What causes earthquakes?

MATERIALS:

- models to demonstrate faulting
- model of seismograph
- seismogram (if available)
- silicone play putty
- graduated cylinder
- 20 wooden checkers
- Student Reference Sheet

PERFORMANCE OBJECTIVES: Students will be able to:

- explain why faults occur.
- define earthquake.
- describe what a seismograph is and its purpose.
- apply the theory of isostasy to the earth.

MOTIVATION:

- Experts are convinced that California is racing toward several major earthquake disasters. They are likely to strike the state's two most heavily populated areas: Los Angeles and San Francisco. Dr. Charles Richter of the California Institute of Technology, father of the famed Richter scale for measuring earthquake magnitude, states that he would not be suprised if a major quake devastated part of California tomorrow. Ask students to describe an earthquake. Then mention that the New York City area has had several minor earthquakes during the 1980s.

PROBLEM: In 1987, southern California had two earthquakes measuring above 5.0 on the Richter scale. What inside the earth is producing a force of this magnitude?

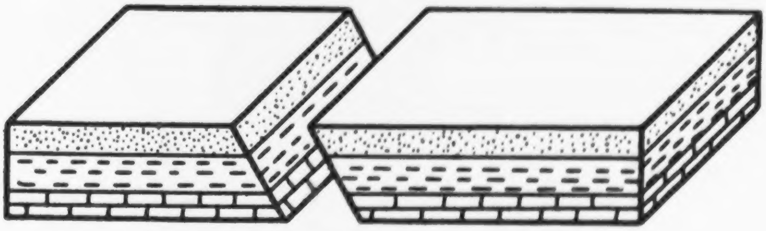
AIM: What causes earthquakes?

DEVELOPMENTAL STRATEGIES:

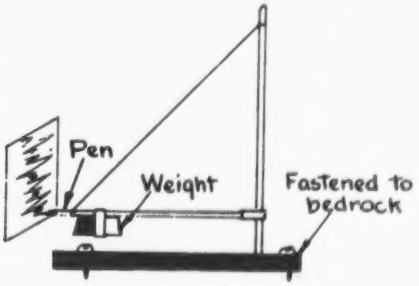
- Ask, "Why is an earthquake so destructive?" Refer to (or show students) newspaper clippings or photographs of earthquake disasters. Point out that much of the loss of property and life is caused by the fires that follow.

- Demonstrate the nature of the mantle with silicone play putty. Pull the putty apart slowly. Ask, "What causes the putty to stretch?" Elicit that the putty is plastic, similar to the earth's mantle, and that a force exerted slowly will cause the putty to change its shape. Now quickly pull the putty apart. The putty snaps. Ask, "How does this demonstration illustrate how an earthquake occurs?"

- Tell students that internal pressure in the earth's crust can cause a break or crack in the ground and that one part of the earth slides past the other. This is called a fault and the movement of the rocks is called faulting. Demonstrate faulting with models (blocks of wood painted in layers). Place them side by side and move them horizontally and vertically in opposite directions. Point out that a sudden movement of the ground cause by faulting is called an earthquake.



- Ask, "How do we measure earthquake intensity?" Demonstrate a model of a seismograph as shown in the diagram below. Point out that the base of the instrument will move with the earth, but the heavily weighted beam will remain in place. A pen, attached to the heavy weight, records on paper the magnitude of a vibration. Have students note that this seismograph measures up and down vibrations of the earth. Show an actual seismogram, if available, and tell the class that the instrument that produced it can be used to locate and measure the intensity of an earthquake.



- Explain the theory of isostasy, which accounts for the rising of land to great heights. Stack about 20 wood checkers (alternate the colors) in a graduated cylinder. Add enough water so that the stack of checkers floats as high as possible. Have students note the level at which the bottom checker rests. Remove one checker at a time and have the students note how the bottom checker is affected.

- Distribute copies of the Student Reference Sheet and assist students to compare this to the continents floating on a plastic layer of earth.

SUMMARY:

- There is evidence that the crust has risen and the sea has receded many times in geological history.

- Earthquake zones are generally associated with recently uplifted regions that are bordered by faults.

- Vibrations in the earth's crust may occur when the equilibrium of a portion of the earth is disturbed. Earthquakes result from the faulting of rock strata by internal forces.

HOMEWORK:

- Why is it important to have earthquake recorders?

- Make a list of areas that have earthquakes.

- Using the theory of isostasy, explain how continents are affected as sediments are carried from the land to the ocean.

ENRICHMENT:

- What is meant by faulting of rocks?

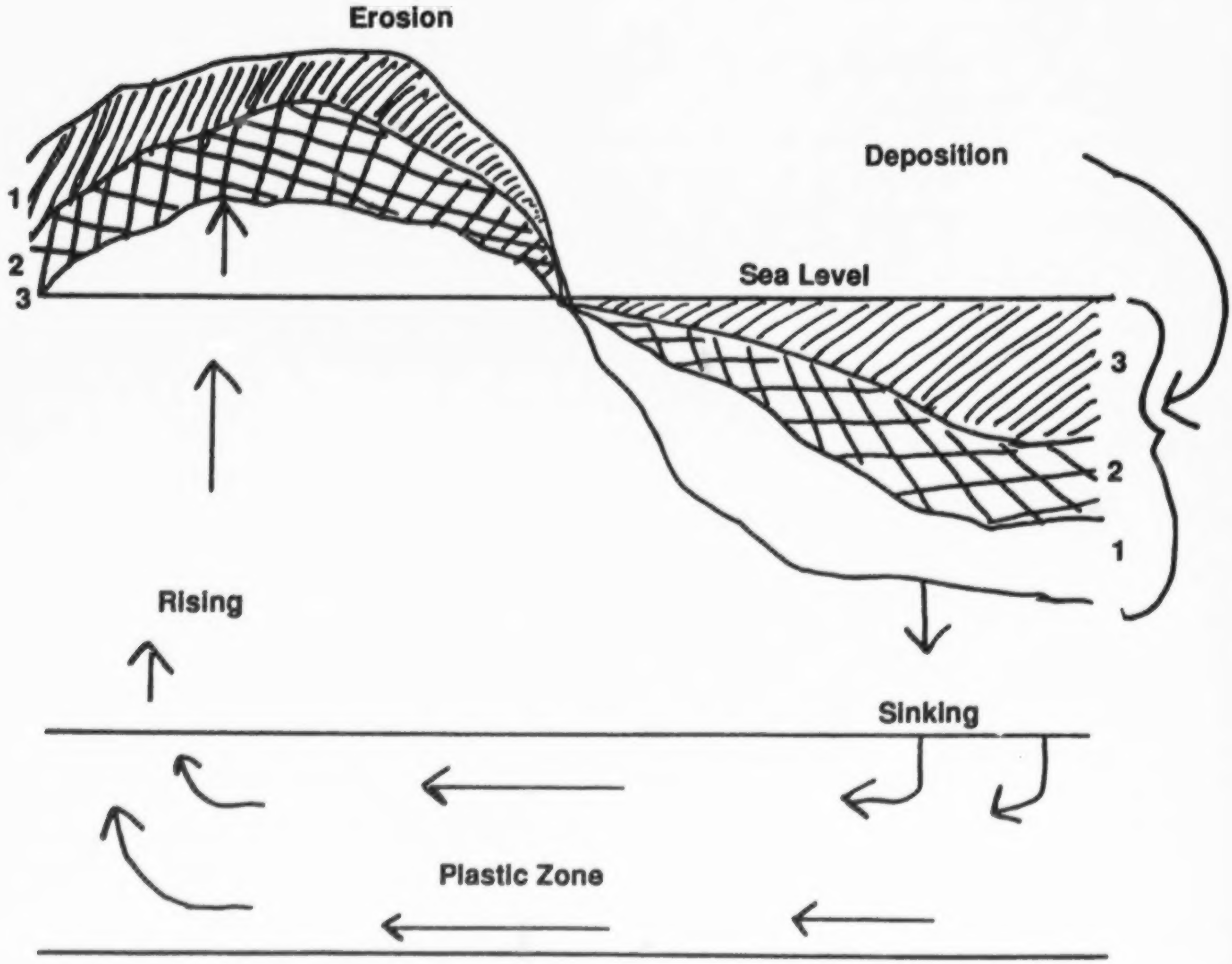
- How are earthquakes produced?

- Draw a diagram of a seismograph and explain how it operates.

- How does the theory of isostasy explain the formation of mountains?

- Why does the New York City area have occasional earthquakes?

Isostasy


Erosion
Deposition
1
2
3
Sea Level
3
2
1
Rising
Sinking
Plastic Zone

177

UNIT II

LESSON E5

TOPIC: Plate tectonics

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D/D1, D7

PROCESS SKILLS: 2, 17

AIM: What is the theory of plate tectonics?

MATERIALS:

- Reference Sheets 1 and 2

PERFORMANCE OBJECTIVES: Students will be able to:

- state the theory of plate tectonics.
- identify major geologic features associated with plate boundaries.

MOTIVATION:

- Distribute copies of Reference Sheet 1. Ask the students to locate three different plate boundaries. Then ask why the boundaries are not the same as political boundaries.

PROBLEM: Why are plate boundaries different from political boundaries?

AIM: What is the theory of plate tectonics?

DEVELOPMENTAL STRATEGIES:

- Explain the theory of plate tectonics to the class. (The earth's crust is divided into a series of rigid plates bounded by ocean ridges, trenches, and active fold belts. The drifting of these plates accounts for the change in location of the continents.)

- If necessary, review continental drift, mountain formation, volcanoes, and earthquakes.

- Distribute Reference Sheet 2 or display it on an overhead projector. Help students analyze each diagram and describe the features produced at each boundary. Record their observations on a chart on the chalkboard.

- Figure 1 on Reference Sheet 2 illustrates a diverging plate boundary. Crustal material is moving apart, or diverging, at this type of boundary. Molten rock material rises from the earth's interior and creates new crustal rock at a mid-ocean ridge. The rock hardens and is pushed outward, away from the ridge. The seafloor is widened as much as 22 cm (8 in.) per year, about the rate at which fingernails grow. This process is called seafloor spreading.

- A converging plate boundary exists where two plates move toward one another. There are two types of converging plate boundaries.

- Figure 2 on Reference Sheet 2 illustrates one type of converging plate boundary. When an ocean plate collides with a continental plate, the dense ocean plate slides under the less dense continental plate. This type of converging plate boundary is called a subduction zone, or oceanic trench. Have students locate the trench on Figure 2. Old crustal rock is melted and destroyed as it descends into the earth's mantle. Deep ocean trenches are created where one plate is sliding beneath another. Plate movement along the boundary produces earthquakes, volcanoes, and mountains.

- Figure 3 on Reference Sheet 2 illustrates the second type of converging plate boundary; when converging continental plates collide, mountain ranges are formed. The Alps and the Himalayas were formed along this type of plate boundary. Draw a line indicating the boundary between the crustal plates on Figure 3.

- A transform fault plate boundary occurs where two plates slide past each other (see figure 4). No crustal material is formed or destroyed along this type of plate boundary. Plates often grind past each other in jolts. Strain builds up along "locked" portions of a transform fault. The strain can be released gradually in many small earthquakes or be released in a single large jolt. The San Andreas fault is a transform fault plate boundary. The same kind of transform fault causes the mid-ocean ridges to be offset in many places.

- Refer again to Reference Sheet 1. This time have students label major geological features such as:

    - Mid-Atlantic Ridge
    - San Andreas fault
    - Iceland
    - Alps
    - Himalaya Mountains
    - North American plate
    - Pacific plate

SUMMARY:

- The theory of plate tectonics is the most current way to account for the rigid plates of the earth's crust that fit together but move slowly. It helps to explain why the earth's surface has ocean ridges, trenches, active fold belts, fault zones, volcanoes, and mountain ranges.

- Mountain ranges should form near the borders of continents, according to the theory. The fact that mountain ranges do occur as long, linear features bordering the continent supports the theory.

- Divergent plate boundaries are geologically active areas where two plates are moving apart. Mid-ocean ridges with underwater volcanoes are commonly found at this type of boundary. One of them, the Mid-Atlantic Ridge, is about 300 kilometers wide and 17,000 kilometers long. It extends along the entire bottom of the Atlantic Ocean. The Azores are a part of this ridge.

- Converging plate boundaries are geologically active areas where subduction takes place. Trenches and island-arcs, along with earthquakes and volcanoes produced by rising magma, are associated with converging boundaries when an oceanic crust "meets" a continental crust. When a continent collides with a continent a mountain range generally forms, e.g., the Himalayas.
- A transform plate boundary or fault zone occurs when two plates slide by one another, e.g., the San Andreas fault in California.

HOMEWORK:

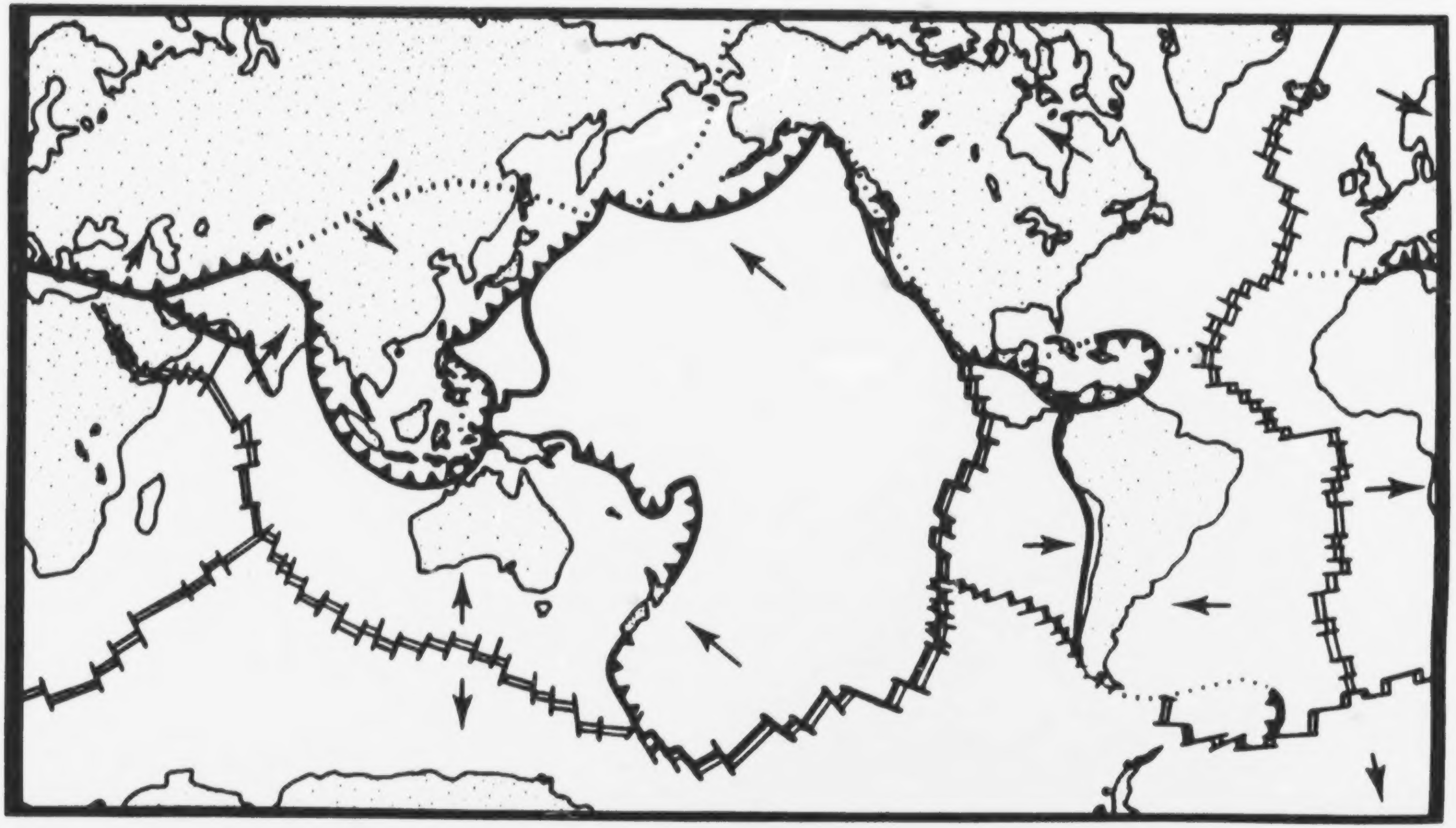
- Explain the theory of plate tectonics.
- What features of the earth's crust form the eastern and western borders of the North American plate?
- What is happening at the Mid-Atlantic Ridge?

ENRICHMENT:

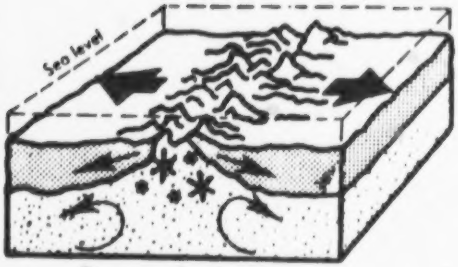
- Describe the "Ring of Fire."

- Show a film or movie about plate tectonics such as:
  - Continental Drift - The Theory of Plate Tectonics. 1980, Encylopaedia Britannica Educational Corp.
  - Our Dynamic Earth. Karol Media, Paramus, N.J.

Plate Boundaries

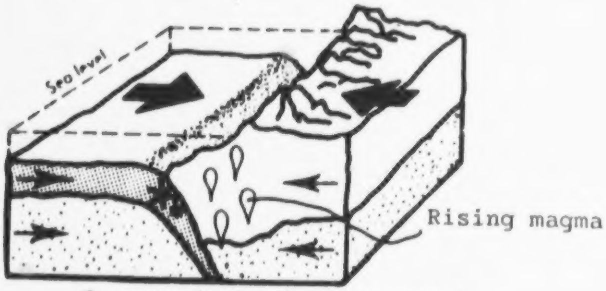

Converging Boundary
Diverging Boundary
Subduction Zone
Uncertain Boundary

REFERENCE SHEET 1



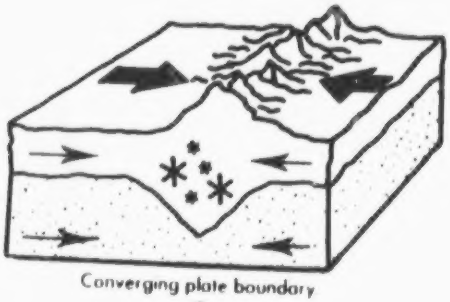
Diverging plate boundary

1


Sea level
Rising magma

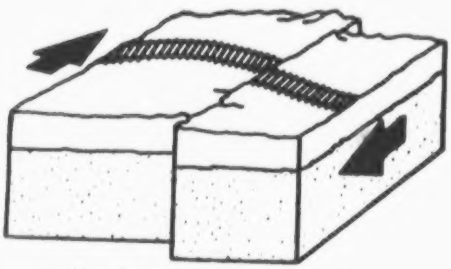
Converging plate boundary showing subduction

2



Converging plate boundary

3



Transform plate boundary

4

☐ Continental crust

▨ Ocean crust

▨ Mantle (asthenosphere)

* Earthquake

UNIT II

LESSON F1

TOPIC: Geologic history of New York City

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D1

PROCESS SKILLS: 2, 7, 9, 14

AIM: Why does New York City have such a varied landscape?

MATERIALS:

- large wall map of New York City (or transparency)
- geology landform models
- transparencies or duplications of Reference Sheets 1, 2, and 3
- educational leaflet #20 "Geology of New York State: A Short Account," available from New York State Museum Publications, Room 3140, CEC, Albany, NY 12230, $1.00. (When ordering request a list of other publications.)

PERFORMANCE OBJECTIVES: Students will be able to:

- describe the surface features that make up the New York City landscape.
- give examples of the type of rocks that underlie New York City.
- reconstruct the events that led to the present New York City landscape using inference and geologic evidence.
- interpret a geologic map and cross section of the bedrock of New York City.

MOTIVATION:

- Display a transparency or a large wall map of New York City. Ask the class to imagine what would be encountered if they were able to drill a hole 167 meters (about 500 feet) below the surface. (The teacher may choose the particular area in which the school is located.) Ask students when opportunities exist to "see" below the earth's surface.

PROBLEM: How can we reconstruct the geologic history of New York City even though there was no one around at the time to record the events?

AIM: Why does New York City have such a varied landscape?

DEVELOPMENTAL STRATEGIES:

- Recall that, on the geologic record, the law of superposition and uniformitarianism are two necessary principles that must be used in reconstructing any geologic events, those in New York City's past included.

- Elicit that the surface features of New York City are the only obvious physical evidence available.

- Point out that there is also other physical evidence available from drill sites and excavations (subway tunnels, water tunnels, etc.). This evidence represents some subsurface information, but it is only available to about 33 meters (about 36 yards) below the surface. As a result, many other types of evidence and inference must be used. Briefly review them for the class. (Evidence includes strike and dip of rock layers, e.g., the underlying structural geology based upon the law of superposition. Inference includes possible reconstruction, based on uniformitarianism, of the events leading up to the present geologic structure.

- Display a transparency of Reference Sheet 1 (a block diagram of the northern tip of Manhattan) and point out the underlying rock layers. Display samples of each type of rock and explain that these are the three main rock types that underlie New York City. Elicit that they are metamorphic rocks and explain that they are over 300 million years old (Carboniferous Period).

- Ask students if they know what happened to all of the rocks that were deposited later. Explain that for some reason these younger rocks are not above the metamorphic rock. Challenge the class to come up with explanations. If the class cannot develop a reasonable hypothesis, provide them with a possible explanation (they were subjected to erosion; some rock layers were never deposited).

- Display a transparency of Reference Sheet 2 (the evolution of the Newark Basin) which illustrates one possible explanation for the present mid-Manhattan landscape. Explain the sequence to the class.

- Summarize the processes that have contributed to the underlying structure of New York City, i.e., deposition, folding and faulting, volcanism, and erosion. Point out that all these processes were important, but the event that is responsible for the present surface of New York City is glaciation.

- Inform the class that about 11,000 years ago, the edge of a huge glacier was on a line through the northern part of Brooklyn and Queens. Manhattan and the Bronx were completely covered by glacial ice up to 333 meters (364 yards) thick.

- Review the effects of glaciation and point out that many of the erosional features associated with glaciation are clearly visible in New York City.

- Use pictures, maps, or photographs of prominent glacial features in New York City to illustrate these features. Many schools are located in places where the features can be seen during a field trip.

- If time permits, display a transparency of Reference Sheet 3 and discuss the major events in the geologic history of New York City.

SUMMARY:

- The present landscape of New York City is a result of many geologic processes.

- Scientists can reconstruct the geologic history of New York City using a combination of evidence and inference.

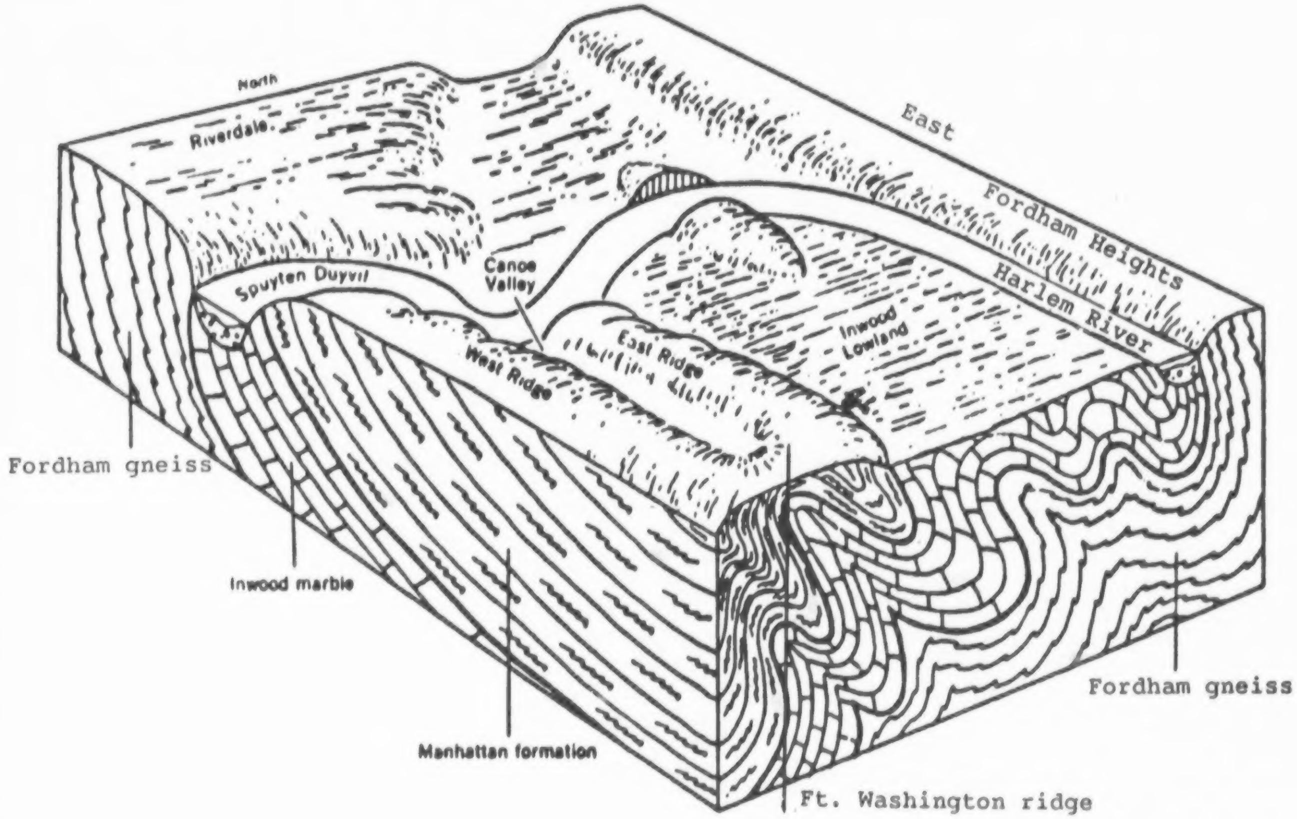
- Much of the topography of New York City is the direct result of glaciation, in particular of the last glacier, which retreated from New York City about 11,000 years ago.

HOMEWORK:

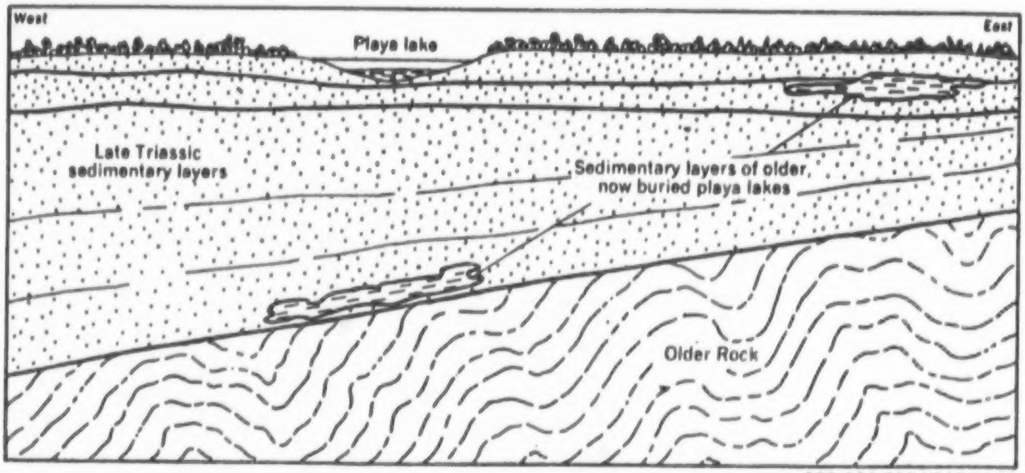
- List the three major types of bedrock underlying New York City.
- List five surface features found in New York City and explain their origins.

ENRICHMENT:

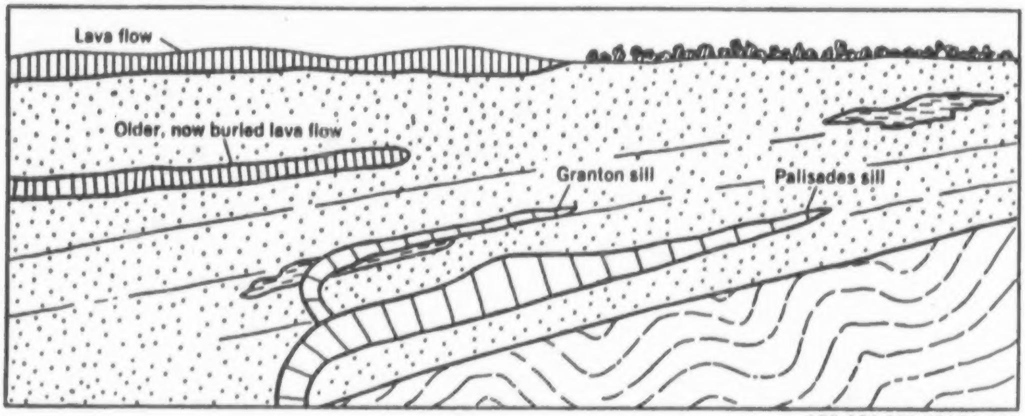
- A field trip to Fort Tyron Park on the Northern tip of Manhattan Island is suggested. Many glacial features and other geologic structures can be observed at first hand.


North
Riverdale
East
Fordham Heights
Harlem River
Spuyten Duyvil
Canoe Valley
Inwood Lowland
East Ridge
West Ridge
Fordham gneiss
Inwood marble
Manhattan formation
Fordham gneiss
Ft. Washington ridge

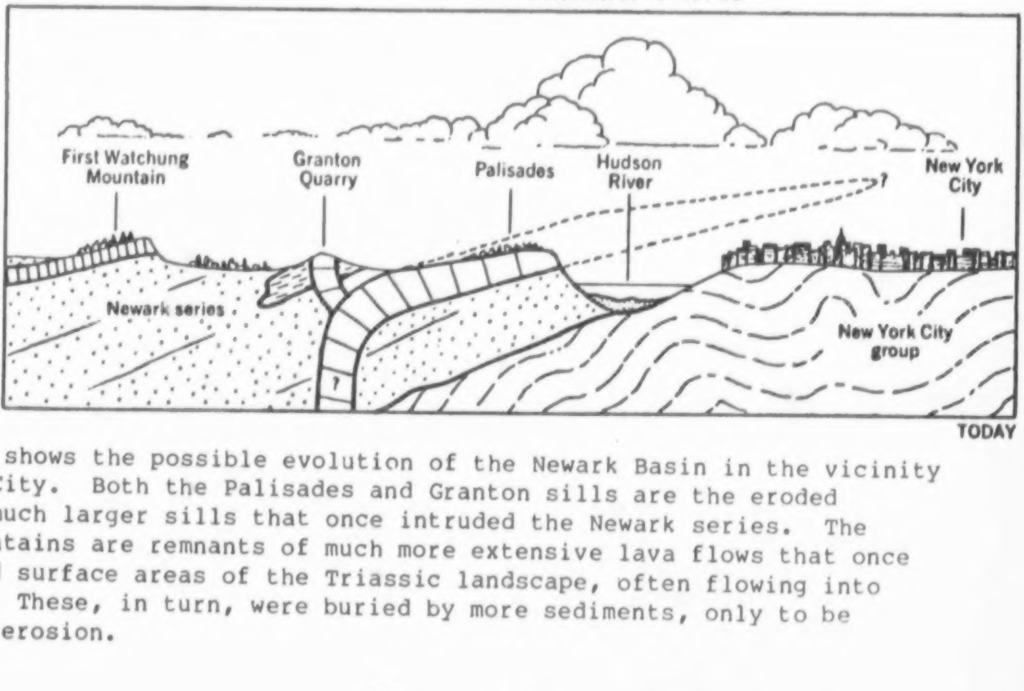
This block diagram, whose vertical scale is exaggerated, illustrates the geologic relationships at Spuyten Duyvil at the northern tip of Manhattan Island. Note that extensive erosion of the anticlines and synclines produced a topography that is an inverted version of the original structures. The anticline in the Canoe Valley has been eroded until the nonresistant marble was exposed to become a valley. But because of the southerly plunge of the rock formations, the resistant schist of the East Ridge and the West Ridge converge at the nose of the south-plunging anticline to form one continuous ridge, the Fort Washington Ridge. This occurs where the Inwood marble in the Canoe Valley plunges beneath the Mannattan formation. (Adapted from a diagram produced by the Geology Department of City College of The City University of New York.)


West
East
Playa lake
Late Triassic sedimentary layers
Sedimentary layers of older, now buried playa lakes
Older Rock

200,000,000 YEARS AGO


Lava flow
Older, now buried lava flow
Granton sill
Palisades sill

185,000,000 YEARS AGO


First Watchung Mountain
Granton Quarry
Palisades
Hudson River
New York City
?
Newark series
?
New York City group

TODAY

This diagram shows the possible evolution of the Newark Basin in the vicinity of New York City. Both the Palisades and Granton sills are the eroded remnants of much larger sills that once intruded the Newark series. The Watchung Mountains are remnants of much more extensive lava flows that once covered broad surface areas of the Triassic landscape, often flowing into playa lakes. These, in turn, were buried by more sediments, only to be reexposed by erosion.

TIMETABLE OF MAJOR GEOLOGIC EVENTS

GEOLOGICAL TIME		MILLIONS OF YEARS AGO	MAJOR EVENTS
CENOZOIC ERA (Predominance of mammals)	Holocene	.02	
	Pleistocene	2	Continental glaciations; Long Island forms; Hudson River becomes an estuary.
	Tertiary		
		65	
MESOZOIC ERA (Age of dinosaurs)	Cretaceous		Deposition of coastal sediments; emergence of continental shelf exposes present coastal plain.
	Jurassic		
	Triassic	200	Opening of Atlantic Ocean; Newark Basin forms; deposition of red beds; volcanic activity.
		225	
PALEOZOIC ERA (Predominance of invertebrate animals)	Permian		Final folding of Appalachian Orogeny
	Carboniferous		Formation of local coal basin.
	Devonian	350	Ancestral Africa jams North America as Proto-Atlantic Ocean closes, causing Acadian Orogeny. Peekskill Granite intruded.
	Silurian		
	Ordovician	435	Offshore volcanism; island arc buckles North American Plate to form ancestral Taconic Mountains from Newfoundland to Alabama; Cortlandt Complex intruded.
	Cambrian		Sediments and volcanics deposited along margins of widening Proto-Atlantic Ocean.
		570	
PROTEROZOIC ERA (Primitive life)		575	Formation of Yonkers Gneiss.
		650	Proto-Atlantic Ocean begins to open.
		1,100	Grenville Orogeny forms high mountains and plateaus from Labrador to Mexico.
			Deposition and consolidation of sediments and volcanics in an early sea.
		2600	
ARCHEOZOIC ERA			No record in New York.
		4600	Formation of Earth and Solar System.

LESSON F2

TOPIC: Topographic maps

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D1

PROCESS SKILLS: 2, 3, 7, 14, 15

AIM: How can we construct and interpret a topographic map?

MATERIALS:

Per lab group:
- contour model kit (with container)
- water
- clear acetate sheet
- non-water-soluble markers

For demonstration:
- topographic maps of various localities in the United States, e.g., Brooklyn, Central Park, Coney Island, Ft. Ticonderoga
- Student Worksheet

PERFORMANCE OBJECTIVES: Students will be able to:

- plan and construct a two-dimensional model of a three-dimensional landform.
- compare the two-dimensional model with the three-dimensional model.
- describe the properties of contour lines.
- define the terms elevation and relief and use these concepts to interpret a topographic map.
- given a topographic map, estimate elevation at any given point and indicate areas of highest and lowest elevation and maximum and minimum slope.

MOTIVATION:

- Display the three-dimensional plastic volcano model and challenge the class to devise a method of representing this model accurately on a two-dimensional surface with the available materials.

PROBLEM: How can we use a two-dimensional surface to represent a portion of a three-dimensional surface of the earth?

AIM: How can we construct and interpret a topographic map?

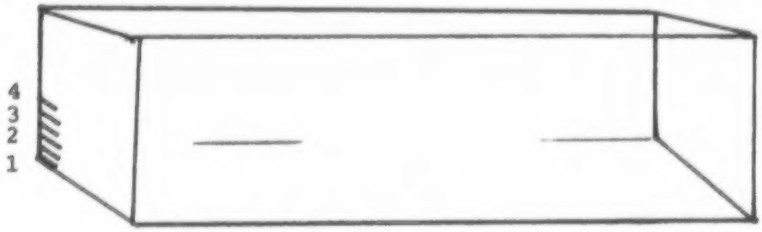
DEVELOPMENTAL STRATEGIES:

- Distribute materials to each laboratory group.

- Elicit several strategies for solving the problem. If the concept of a line is not suggested, present the concept and explain that this is the simplest and most convenient way of representing points of equal elevation.

- Demonstrate the method for beginning to map the landform.

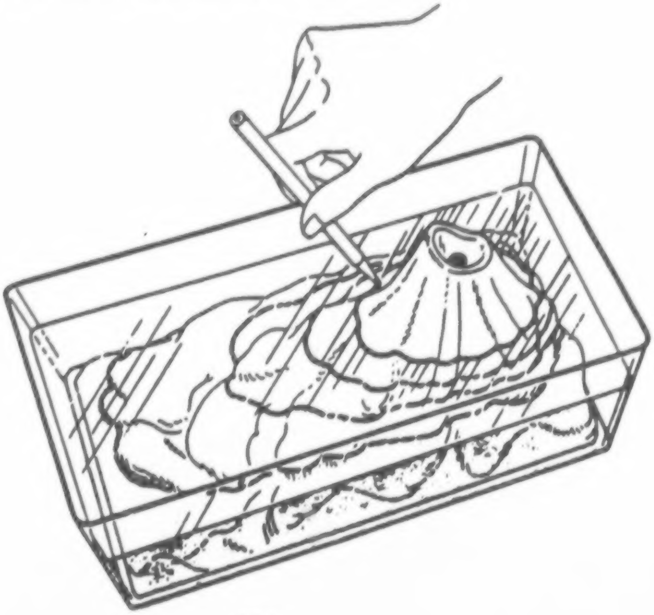
  - Using the marker, draw a short horizontal line one centimeter above the bottom of the plastic container. Continue drawing similar lines above the first line at intervals of 1 centimeter until you reach the top of the container. Label each mark as illustrated.



  - Place the landform into the plastic container. Make sure the container is on a level surface.

  - Carefully fill the container with water up to the 1cm mark. Do not continue until each lab group has done this successfully.

- Elicit that the water now makes a shoreline on the plastic model. Guide the students to understand that this shoreline is the SAME HEIGHT OR ELEVATION EVERYWHERE ON THE MODEL (1 centimeter).



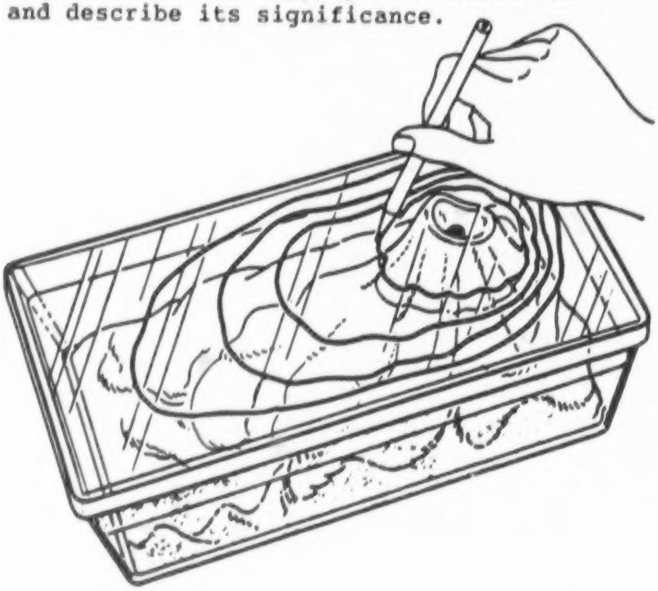
- Tell the students to draw a line around the model everywhere the water makes a shoreline. Elicit that this line is 1 centimeter high.

- Elicit from the students some of the characteristics of this line (equal elevation, no sharp corners, a continuous loop, does not cross itself or divide into more than one line).

- Instruct students to perform the same procedure at the 2-, 3-, 4-cm marks, etc., until the container is full.

- When the container is full, have the students empty the water from the container and make some further observations about the lines that they have drawn on the model.

- Tell the students to place the lid on the box and place the transparent sheet on top of the lid. Looking directly down on the model, trace each line on the sheet and label it with the appropriate elevation. Introduce the term contour line and describe its significance.



- Elicit that these contour lines represent the shape of the volcano on a flat, two-dimensional surface and that certain information can be obtained from them.

- Challenge the students to interpret the contour lines and come up with some generalizations and rules for contour lines such as:

  - All points on the contour line have the same elevation.
  - The vertical distance between the lines is the same. This is called a contour interval.
  - Contour lines never cross or divide.
  - Contour lines are evenly spaced only where the slope is uniform; generally the spacing is uneven.
  - Where the slope is steep, contour lines are close; where the slope is gentle, they are far apart.

SUMMARY:

- A topographic map is the representation of a three-dimensional portion of the earth's surface on a plane (two dimensions).
- Topographic maps contain much information and differ from other maps mainly in showing relief by contour lines.
- Distance is determined on the map by means of a scale. The scale is the ratio between the distance between any two points on a map and the distance between the same two points measured on the ground.
- Relief is the difference in elevation between the high and low points of a land surface. It can be determined from contour lines on a map.
- A contour line is a line on a map connecting points of equal elevation above sea level.
- All points on a given contour line have the same elevation.
- Contour lines never cross one another.
- A steep slope is represented by closely spaced contour lines; a gentle slope by widely spaced contour lines.
- Uniformly spaced contour lines represent a uniform slope.
- The lowest elevation is usually on the major stream where it leaves the map.
- A contour interval is the difference in elevation between two adjacent contour lines.
- Contour lines are drawn at a fixed elevation interval for a particular map.

HOMEWORK:

- Complete the Student Worksheet.

ENRICHMENT:

- Construct a profile of the map that was completed for homework.

UNIT II
Lesson P2

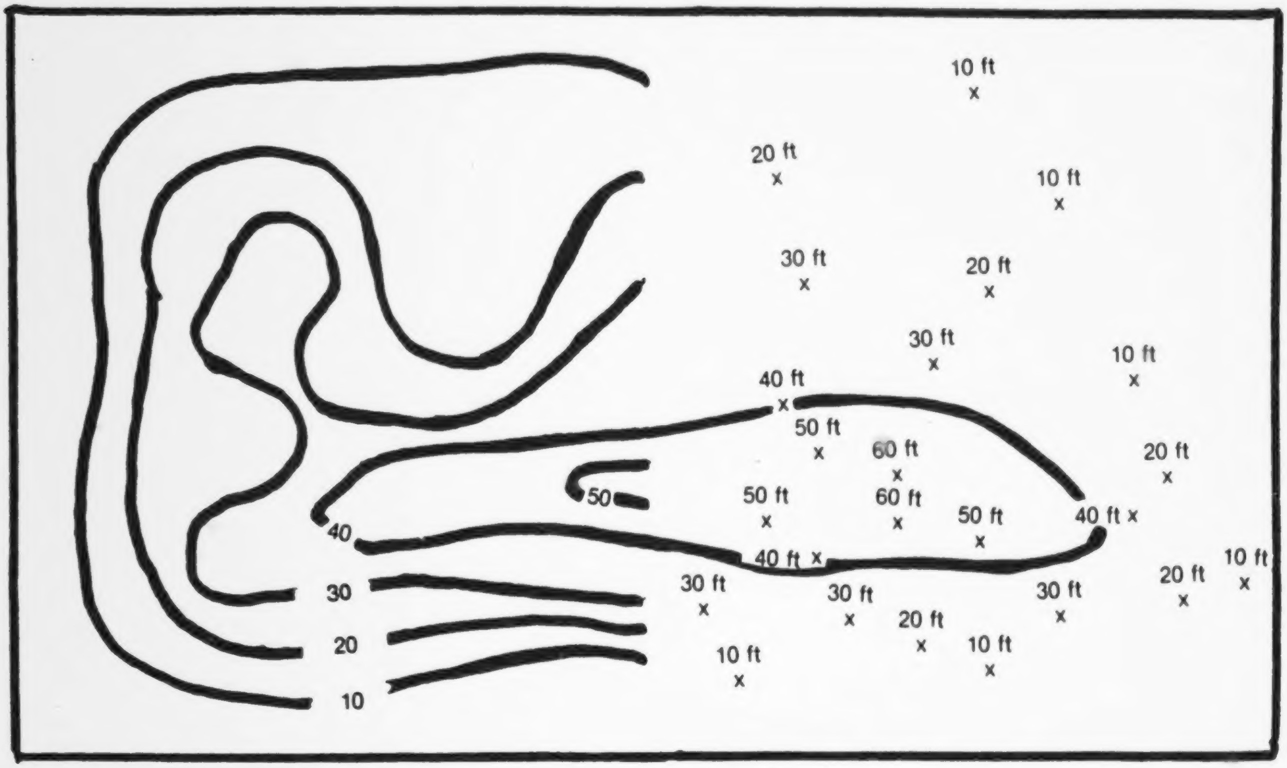
STUDENT WORKSHEET

NAME ______________________________ CLASS ________________ DATE ________________

On the topographic map below the contour lines are only half complete. Using a pencil, finish each contour line based on the information provided on the map. A number of elevations are provided on the blank side of the map. Use the skills you developed and observations you made during the class activity to complete the map. The elevations are marked like this:

40 ft
x

The "x" below the elevation is the point through which the 40-ft. contour passes. The 40-ft. contour has been completed for you.


10 ft
20 ft
10 ft
30 ft
20 ft
30 ft
10 ft
40 ft
50 ft
60 ft
20 ft
50
50 ft
60 ft
50 ft
40 ft
40
40 ft
10 ft
30
30 ft
30 ft
30 ft
20 ft
20
20 ft
10 ft
10 ft
10 ft
10

Contour Interval 10 feet

- After completing your map, see if your contour lines follow all the rules.
- What is the value of the highest contour line?
- Which part of the map has the steepest slope?
- Why can't contour lines cross each other?

UNIT III

LESSON 1

TOPIC: Coastal features

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D21

PROCESS SKILLS: 1, 2, 4, 6, 9, 14

AIM: What features are found along continental coastlines?

MATERIALS:

- Reference Sheets 1, 2, and 3, and Student Handout
- aerial photograph of Cape Cod
- diagram of Cape Hatteras
- pictures of Big Sur
- map or diagram of coastline and submerged land areas

PERFORMANCE OBJECTIVES: Students will be able to:

- describe shorelines, beaches, estuaries, lagoons, and marshes.
- identify the economic uses of different coastal formations.
- locate continental shelf, slope, and rise on a map.

MOTIVATION:

- Display Reference Sheet 1 and ask students to describe what they see.

- Elicit suggestions from the students as to how the series of barrier islands was formed and how the coastline became so irregular.

PROBLEM: How can we describe coastal formations found at the seashore and how are they formed?

AIM: What features are found along continental coastlines?

DEVELOPMENTAL STRATEGIES:

- Distribute copies of Student Handout. Assist students in using the handout to describe the formation of barrier islands.

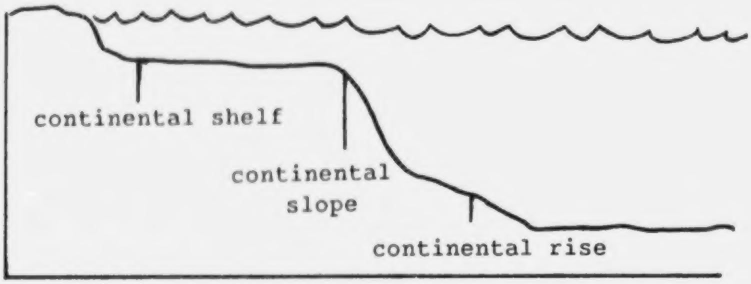
  - Barrier island formation and migration along the Atlantic and Gulf coasts: a) About 11,000 years ago, sand bars grew as melting glacial water filled the ocean basins and flooded the continental shelves. Wind and waves stirred the loose sands on the continental shelf, building sand-bar "islands."
    (b) Sea level continued to rise, causing the barrier islands to move closer to shore. New sand bars grew farther out on the continental shelf, breached the surface, and became barrier islands. Shallow bays developed near the shore.
    (c) The rise of sea level continued to cause barrier islands to migrate inland. Some islands joined with the coast and others grew and moved inland.

(d) The rise of sea level slowed and barrier islands stabilized. Between 3,000 years ago and the present, barrier islands have continued to migrate very slowly toward the mainland. Within the last 50 years, the rise of sea level has accelerated. The rising water has caused worldwide erosion of barrier islands and other coastal areas. Moreover, as sea level rises, barrier islands move closer to the mainland.

. Display Reference Sheet 2 on the overhead projector and ask students why these are called lagoons rather than bays or estuaries. Elicit that lagoons do not have a dependable source of fresh water and therefore do not receive a continuous supply of fresh water, as do estuaries. Water constantly evaporates from the lagoons, resulting in an increase in salinity, and they become more saline than the ocean beyond. Indicate that salinity decreases only during times of plentiful rainfall.

. Display Reference Sheet 3 on the overhead projector. Ask students to compare and contrast the two different kinds of coastlines. Ask for reasons why they developed differently. Elicit that one looks as though it may have been flooded by a rising sea level and the other may have been formed by tectonic forces uplifting the land. Display a picture of coastal California, if possible, to discuss this.

. Pose the question, "What do you think the ocean bottom looks like near the coastline?" Display a cross-sectional diagram similar to the one below, which shows a typical continental shelf, slope, and rise.



. Ask the class to list several reasons why coastline areas are heavily populated and why they are of such great economic importance. Elicit their use as recreation areas, seaports (shipping and transport), and breeding grounds for important fish species.

SUMMARY:

. A coastline occurs where the land meets the water.

. A coastline may be regular or irregular.

. The east coast of the United States is considered irregular while the west coast is considered regular.

. Barrier islands are formed when wave action moves loose sand.

. Longshore drift is the movement of sediment by a current along the coastline.

- Barrier islands may produce lagoons or estuaries.

- A lagoon contains water that is very salty due to evaporation.

- An estuary occurs where fresh water meets salt water, and is characterized by water having a gradient of salinity that decreases as the distance from the ocean increases.

- Bays are economically important because they provide safe harbors for shipping and are breeding grounds for important fish species.

HOMEWORK:

- Define coastline.

- What is the difference between a regular and an irregular coastline?

- How are barrier islands formed?

- What is the relationship between barrier islands and longshore drift?

- How is a lagoon different from an estuary?

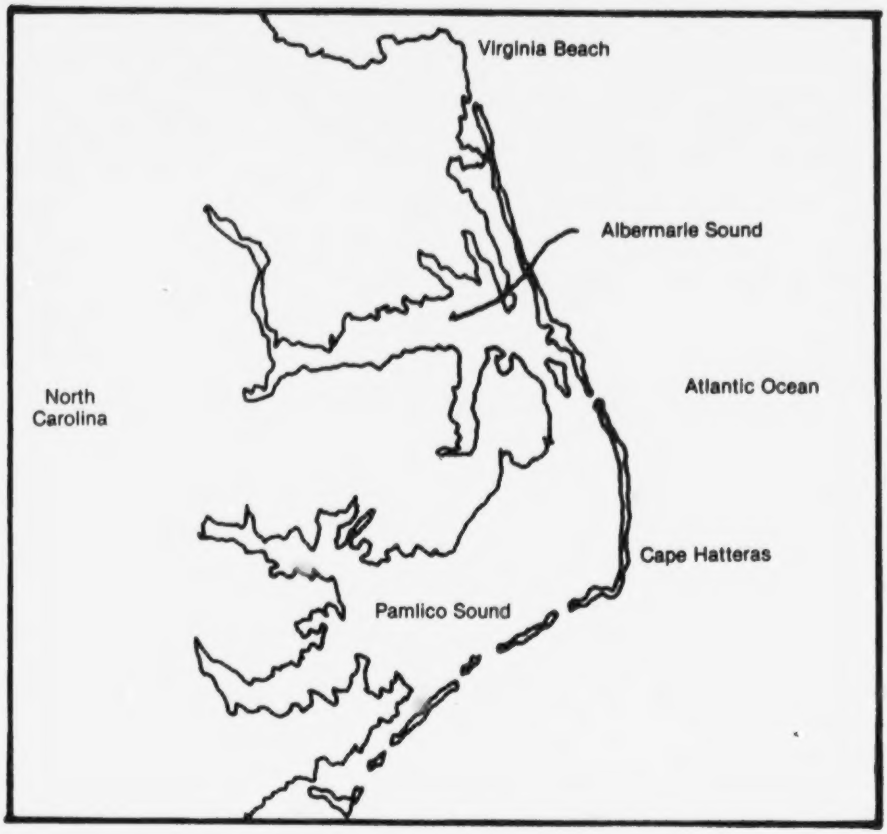
- Give two reasons why bays are economically important.

- Why are irregular coastlines more desirable than regular coastlines?

ENRICHMENT:

- Write a report on the life cycle of one of the different kinds of plant and animal life found in estuaries. Include in your report the part of the estuary that this organism inhabits.

- Bring in a large road map of Long Island and identify some of the formations discussed in class.


Virginia Beach
Albermarle Sound
Atlantic Ocean
North Carolina
Cape Hatteras
Pamlico Sound

Pamlico Sound estuary formed behind the barrier islands of Cape Hatteras, North Carolina.

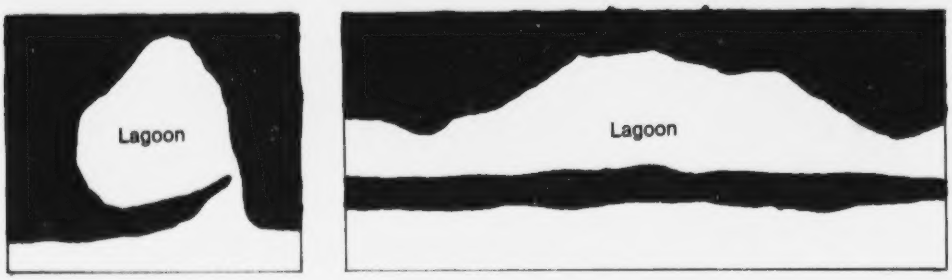
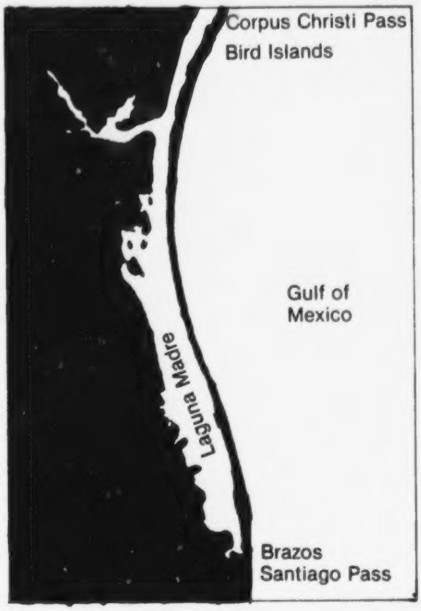
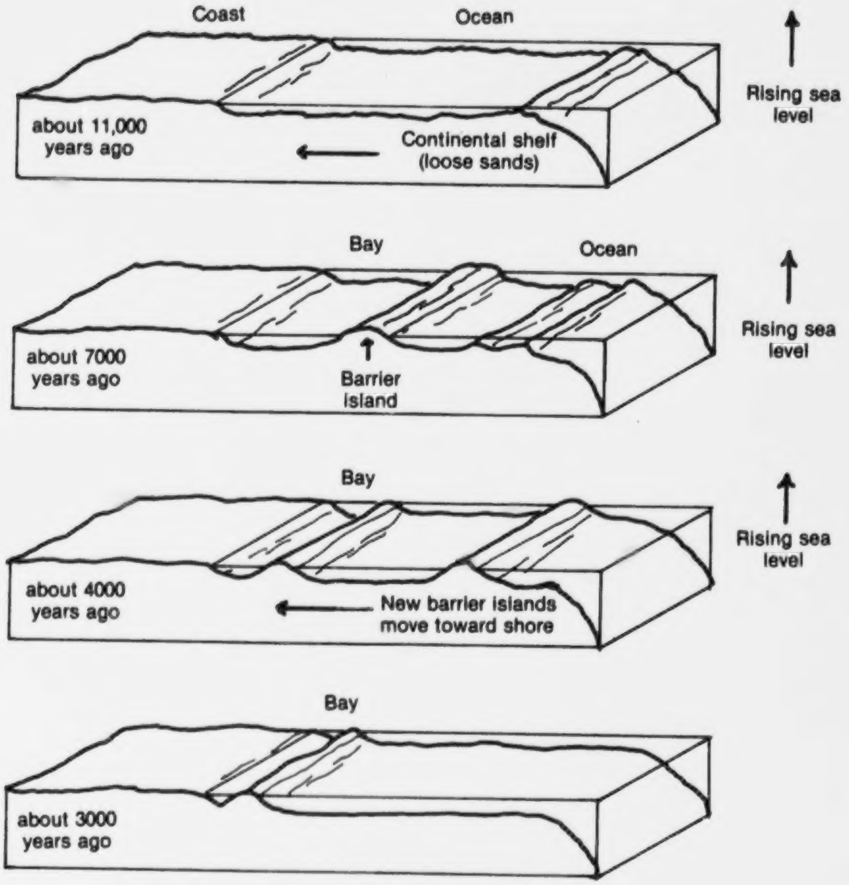

Lagoon
Lagoon

Diagram of lagoon formed by (a) a spit which will eventually become a baymouth bar and (b) a barrier island.

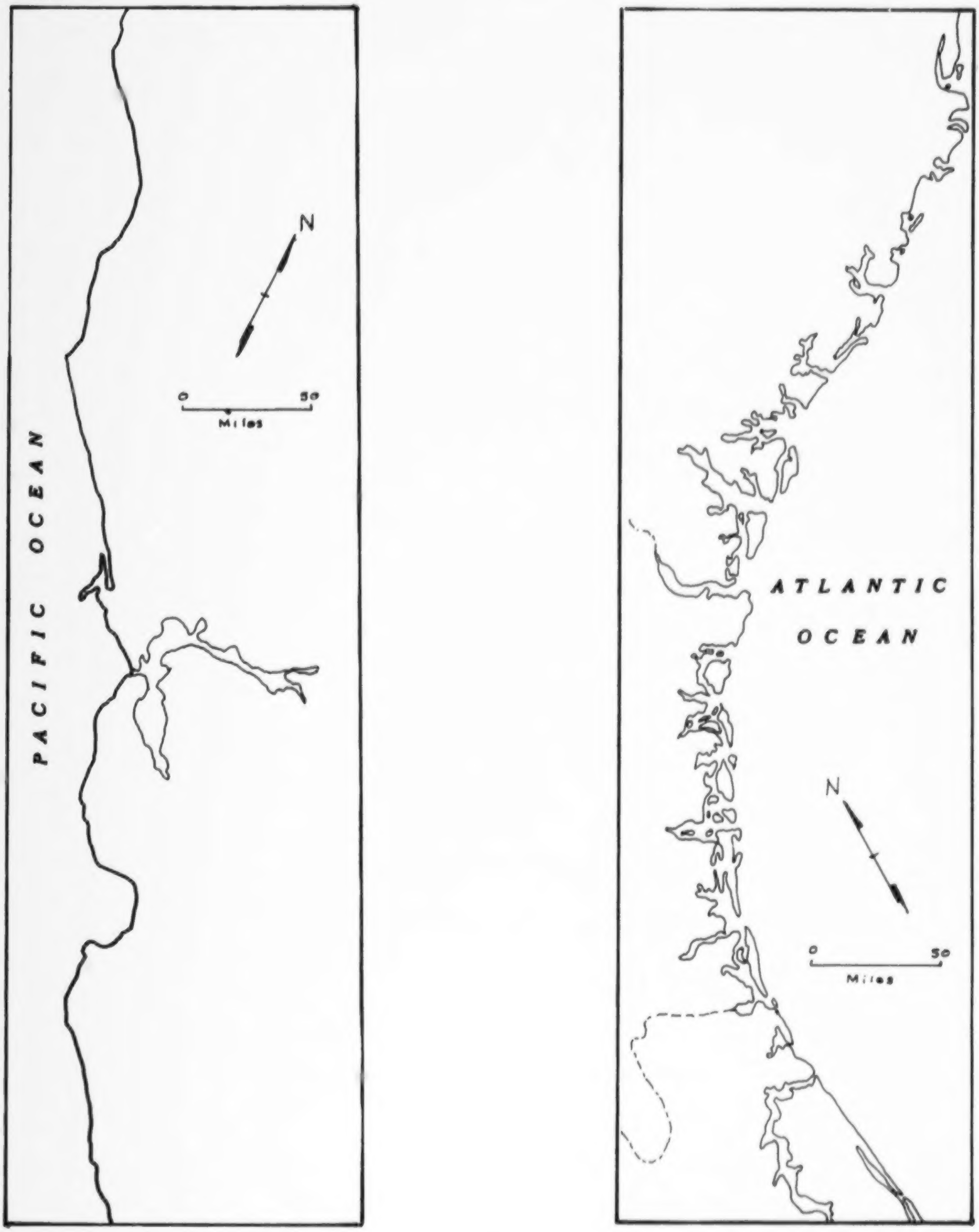

Corpus Christi Pass
Bird Islands
Gulf of Mexico
Laguna Madre
Brazos Santiago Pass

Map of Laguna Madre, which extends from near Corpus Christi to Brownsville, Texas.


Coast
Ocean
about 11,000 years ago
Continental shelf (loose sands)
Rising sea level
Bay
Ocean
about 7000 years ago
Barrier island
Rising sea level
Bay
about 4000 years ago
New barrier islands move toward shore
Rising sea level
Bay
about 3000 years ago

UNIT III
Lesson 1

REFERENCE SHEET 3


PACIFIC OCEAN
N
0
50
Miles
ATLANTIC OCEAN
N
0
50
Miles

Segments of highway road maps showing relatively straight coastline of California compared to highly irregular coastline from South Carolina to Florida.

LESSON 2

TOPIC: Origin of the ocean basins (continental drift)

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D22, D5

PROCESS SKILLS: 1, 2, 14, 15, 17

AIM: How did the ocean basins originate?

MATERIALS:

. traced map of the continents
. Reference Sheet 1 from lesson E5
. Reference Sheets 1 and 2

PERFORMANCE OBJECTIVES: Students will be able to:

. describe plate tectonic theory.
. describe how the topography of the ocean floor was formed.

MOTIVATION:

. Glue a traced outline of the world onto a piece of cardboard. Cut out each continent and the oceans. (This should be done prior to the lesson by the students or teacher.) Have two students attempt to fit the pieces together to form one giant continent. Once this task has been completed, ask students what they think this shows. Students should infer that at one time all the continents were attached. Indicate that geologists noticed that they fit together but could not explain why they would separate. Ask students if they know of any process that would cause continents to drift.

PROBLEM: How did large oceanic areas between the continents form?

AIM: How did the ocean basins originate?

DEVELOPMENTAL STRATEGIES:

. Tell students that today we have a theory that attempts to explain continental drift, or breaking apart of the continents, and that it is called plate tectonics.

. Place the diagram of the mid-ocean ridge (Reference Sheet 1) on the overhead projector or draw it on the chalkboard.

. Elicit an analysis of this diagram by posing the following questions:

- What is magma? (Liquid material that can solidify into rock.)

- Why does magma harden into the lithosphere on rock when it reaches the mid-ocean ridge? (The surrounding water cools it.)

- What causes the magma to rise as shown in the diagram? (Because it is hot.)

- What letters represent the newest lithosphere on the diagram? (C & D)

- What letters represent the oldest rock on the diagram? (A & F)

- Describe what the continents are floating on in this diagram. (The lithosphere.)

- What do you think caused the continents to split apart? (A brief discussion on continental drift should follow. The discussion should include Pangaea.)

. Finally, draw an analogy between this and a horizontal conveyor belt or escalator in a department store.

. Refer the students to any material in the text that might assist in relating the concept of continental drift, e.g., maps, charts, diagrams, or textual material.

. Ask a student to separate the cardboard continents into the positions they are in today and tape them to the chalkboard with tape.

. Display a transparency of Reference Sheet 2 or draw it on the chalkboard. Indicate that this is a more detailed diagram which might better explain the mechanism that causes continental drift. Students should name all parts of the diagram before it is interpreted.

. Pose the following questions:

- What causes the movement of magma within the asthenosphere? (The hot magma rises.)

- Why? (Hot magma is less dense than cool magma.)

- What causes the lithosphere to move from the mid-ocean ridges? (Plates that plunge under the continents at subduction zones are pulled toward the continents by the parts that are being pulled down by the earth's gravitational field. This happens because the solid crust is more dense than the hotter liquid or plastic mantle. Ocean bed plates are pulled in opposite directions, increasing the width of the gap at the mid-ocean ridge. Liquid magma is pushed up into the gap and then solidifies into new crustal rock.)

- If the lithosphere continues to grow at the mid-ocean ridges, does this cause the earth to expand? (No, because it returns to the mantle at the subduction zones.)

. Indicate that this explanation for continental drift is only a theory and is yet to be proved. However, it does explain some of the topography of the ocean floor and there is evidence which supports this theory.

. Ask students how the mid-ocean ridges affect the topography of the ocean floor. Using the information from Reference Sheet 2, have students attempt to explain how sea floor spreading at the mid-ocean ridges can form the following topographic features:

- underwater volcanoes: formed from lava at mid-ocean ridges.
- volcanic islands: underwater volcanoes that rise above the surface of the earth at the ridges or other hot spots.
- deep sea trenches: ocean-bed crustal material is returning to the mantle.
- seamounts: an isolated volcanic hill that may once have been at the mid-ocean ridge.
- abyssal plains: flat surfaces of older lithosphere that have moved away from the mid-ocean ridge.

. Finally, refer students to the map of the plates of lithosphere that cover the earth (Reference Sheet 1, Lesson E5). Ask students to count the six major and minor plates. Indicate that the plates are all moving in different directions.

SUMMARY:

. A mid-ocean ridge is found in the Atlantic Ocean and extends to other oceans.

. Magma is upswelling along the rift valley which is at the center of the ocean ridge.

. The magma becomes new crust as it cools and hardens.

. Ocean floor crust is pulled under the continents by gravitational force at subduction zones. This pulls the plates apart.

. All the continents are thought to have formed one large landmass called Pangaea.

. The continents have been separating to their present positions over the last 200-million years.

. There are six major plates and several minor ones.

. The continents rest on the six major plates and move with them.

HOMEWORK:

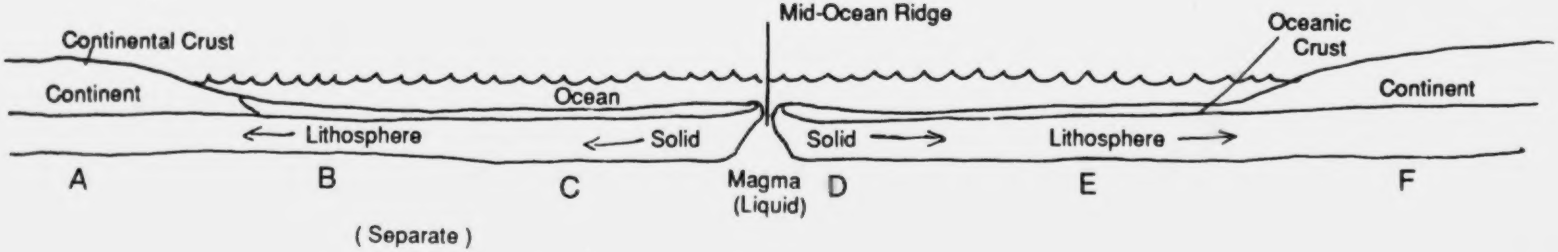
- Explain what scientists think has happened to the continents over the past 200-million years.
- How does the theory of plate tectonics explain continental drift?
- How many major tectonic plates are found on earth?
- Name five topographic features created by moving plates.
- What is happening along the mid-ocean ridges?
- Using the theory of plate tectonics, describe how continents move.

- Why is plate tectonics still considered a theory?
- If the sea floor is spreading at the mid-ocean ridges, does this mean that the earth is getting larger?
- A crustal plate moves about 10cm a year. How far will the crustal plate move in a) 10 years, b) 100 years, c) 10,000 years?
- Explain why continents do not fit exactly into one another like the pieces of a puzzle.
- Look at a map of the world. According to continental drift theory, which continents are going to crash into each other in the future? Where have they collided in the past? (Folded mountains - Appalachian and Himalayas)

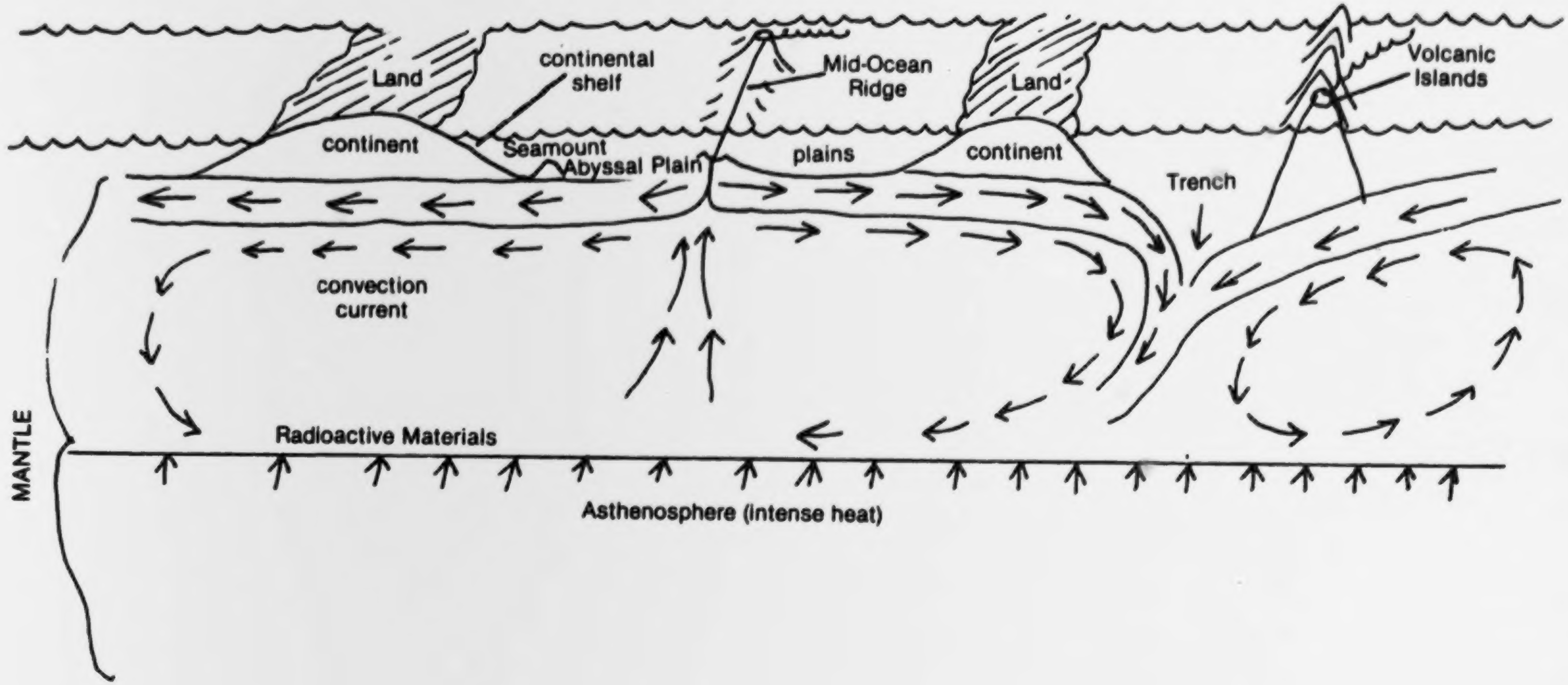
ENRICHMENT:

- Draw a diagram of all six major and minor tectonic plates. Include the continents, mid-ocean ridges, and major mountain ranges.

Reference Sheet 1


Mid-Ocean Ridge
Continental Crust
Oceanic Crust
Continent
Ocean
Continent
Lithosphere
Solid
Solid
Lithosphere
Magma (Liquid)
A
B
C
D
E
F
(Separate)

Reference Sheet 2


Land
continental shelf
Mid-Ocean Ridge
Land
Volcanic Islands
continent
Seamount
Abyssal Plain
plains
continent
Trench
convection current
MANTLE
Radioactive Materials
Asthenosphere (intense heat)

UNIT III
Lesson 2

208

UNIT III

LESSON 3

TOPIC: Ocean floors and underwater topography

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D22, D5

PROCESS SKILLS: 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 14, 15

AIM: How can scientists obtain a profile of the ocean floor?

MATERIALS:

For the teacher:
- topographical map of the United States
- map or slides of the ocean floor
- Teacher Laboratory Worksheet

Per lab group:
- very large cardboard box (with cover)
- string (about 1 meter long)
- fishing weight
- meterstick
- landforms
- Student Laboratory Worksheet
- masking tape

PERFORMANCE OBJECTIVES: Students will be able to:

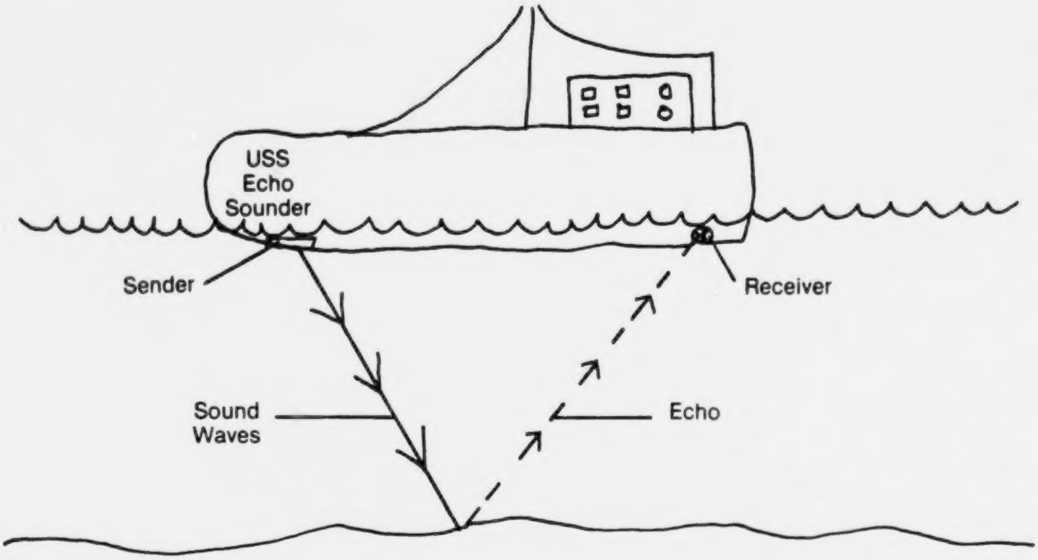
- describe how scientists obtain a profile of the ocean floor.
- identify different features of the ocean floor.
- describe how the mid-Atlantic ridge contributes to sea floor spreading.

MOTIVATION:

- Draw a diagram on the chalkboard similar to the one below (be sure to include the formula for depth) and have the students analyze it. Elicit answers to the following questions:
  - According to this diagram, how do we obtain a profile of the ocean floor? (The profile is obtained by determining the time it takes for the sound waves to travel to the bottom and bounce back to the ship.)
  - Use the formula on the chalkboard to calculate the depth if it took 4 seconds for the sound wave to return back to the ship.

$$\frac{(4\ \text{sec})(1460\ \text{m/sec})}{2} = 2920\ \text{meters}$$

$$\text{Depth (meters)} = \frac{(\text{sound travel time})\,(1460\ \text{m/sec.})}{2}$$

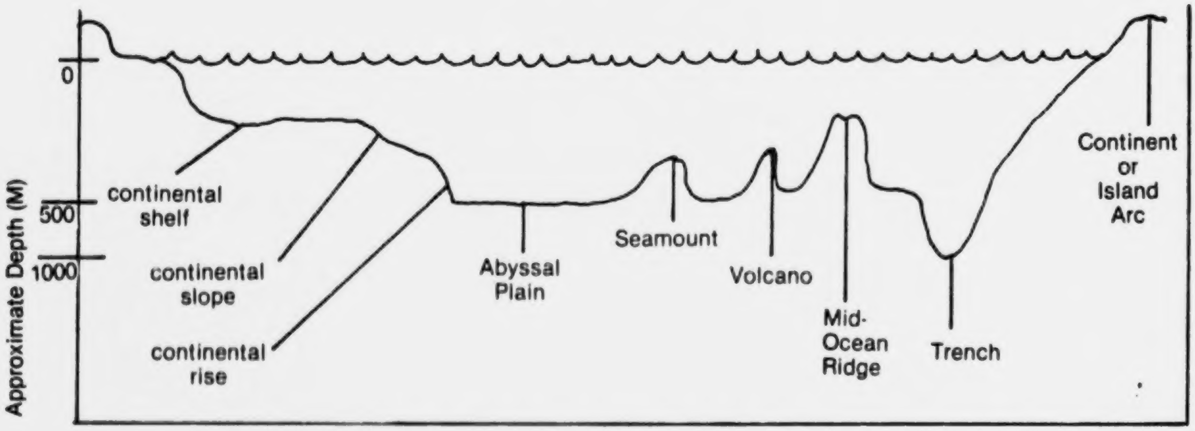

USS
Echo
Sounder
Sender
Receiver
Sound
Waves
Echo

PROBLEM: What does the bottom of the ocean floor look like?

AIM: How can scientists obtain a profile of the ocean floor?

DEVELOPMENTAL STRATEGIES:

- Direct students' attention to a profile of the major geological features of the ocean floor similar to the one illustrated below. Draw it on the chalkboard or display it on an overhead projector.


Approximate Depth (M)
0
500
1000
continental
shelf
continental
slope
continental
rise
Abyssal
Plain
Seamount
Volcano
Mid-
Ocean
Ridge
Trench
Continent
or
Island
Arc

. Discuss the various features and compare them to those found on land.

abyssal plain - Great Plains
trench - Grand Canyon, river valley
mid-ocean ridge - mountain range
seamount - mesa, flat-topped hill
continental slope - hillside, mountainside
volcano - Mount St. Helens

. This verbal comparison should solidify the images of seascapes for students. Present a wall map of the world's ocean floors.

- Locate the mid-ocean ridge, a seamount, an underwater volcano, continental slopes, etc. (Have the students participate actively by pointing out these features on the map.)

. Place the following data on the chalkboard and point out the deepest trenches on the wall map.

NAME	DEPTH	LOCATION
Marianas trench	11.0 km (36,200 ft.)	Guam
Philippine trench	10.5 km (34,500 ft.)	Philippines
Naras trench	9.2 km (30,200 ft.)	Puerto Rico
Middle America trench	6.7 km (22,000 ft.)	Eastern Pacific

. Elicit answers to the following questions:

- Where is the deepest part of the ocean located? (Marianas trench, near Guam)
- What is the depth in miles of the Philippine trench?
- Which trench is nearest New York City?
- Has anyone been to the bottom of these trenches?

. After a discussion, indicate that in 1960 an underwater vehicle (a bathyscaphe) named the Trieste was lowered to the bottom of the Marianas trench.

- What are some of the difficulties working in such a deep environment? (Water pressure and darkness.)

- What do the Hawaiian Islands and Iceland have in common? (Both were once undersea volcanoes that grew tall enough to become islands.)

SUMMARY:

. Early oceanographers used heavy weights attached to cables to determine the profile of the sea floor.

. This device was inaccurate for several reasons: a continuous profile is impossible to obtain; some areas are not recorded; the line is not always vertical.

. Today scientists use a device called an echo sounder to measure depth.

. The formula that is used to determine depth is:

$$\text{depth} = \frac{(\text{travel time})(1460\ \text{m/sec})}{2}$$

. Some seascape formations are: continental shelf, contintal slope, continental rise, abyssal plain, seamount, volcano, mid-ocean ridge, trench.

. The Marianas trench is the deepest part of the ocean at 11.0 km (36,000 ft.).

. Both Hawaii and Iceland are islands created by underwater volcanoes that grew above the surface of the water.

HOMEWORK:

- Explain how the profile of the ocean bottom was formerly obtained.
- What new method is used by oceanographers to determine ocean depth and profile?
- Name four common ocean bottom features and compare them to surface features.
- Near which part of the sea floor do people swim?
- Explain how volcanic islands are formed.
- What is the difference between an ocean ridge and an ocean trench?
- Explain why using weighted ropes was a poor method of obtaining a profile of the sea floor.

ENRICHMENT:

- Make a clay model of the ocean bottom formations in a shoe box.
- Write a short report on one of the sea floor formations.
- Draw a diagram of a typical sea floor bottom on poster paper.
- Write a report on the discovery of the deepest ocean floor trenches.
- Write a report on the bathyscaphe Alvin or on the Trieste.

PROBLEM: How can we obtain a profile of the bottom of the carton?

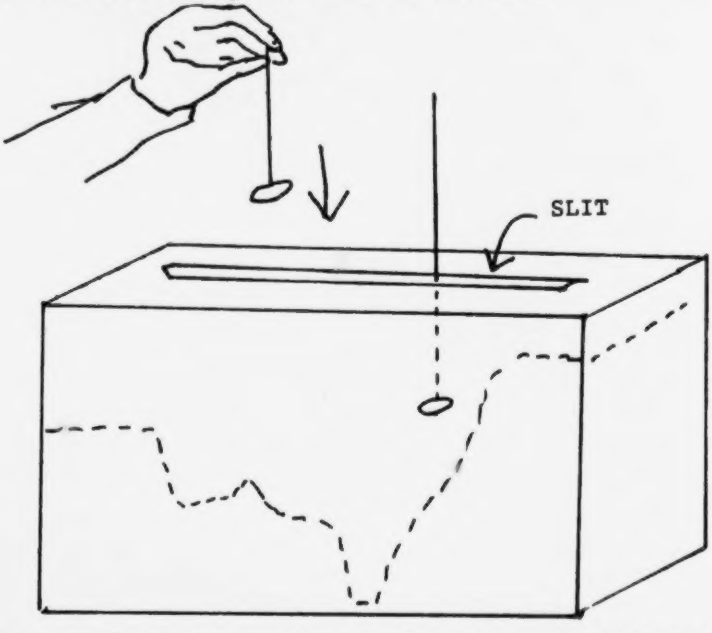
HYPOTHESIS: A string and a weight can be used to determine different depths.

MATERIALS: large cardboard box (with cover), string, fishing weight, meterstick, landforms, masking tape

PROCEDURE:

. Distribute to each lab group a large closed cardboard carton whose lid has a narrow opening down the middle; students should not be able to see inside the carton. Different "landforms" should have been placed at the bottom of the carton. They may be made from books stacked at different heights, clay, or any other suitable material. Be sure the students do not see the shape of their landform.

. Supply each lab group with a weighted string. Ask a student to take depth soundings every 3 centimeters along the slit in the box.



. Each student should be assisted by another student to more accurately measure each sounding. Place masking tape markers along the slit to mark where each sounding should take place. As the soundings are announced, instruct students in their seats to graph the results.

. Ask the students to compare their graphs to the boxes on the floor. (They are nearly the same size, but not exactly.)

- What problems did early oceanographers encounter by using this method? (It is inaccurate because you do not get a sounding for all parts of the bottom; no continuous line.)

- What problems might be caused by ocean currents between the surface and the bottom? (The line will not hang vertically.)

- How do oceanographers obtain a profile of the ocean floor today?

DATA COLLECTION: Present a copy of the profile to the class.

CONCLUSIONS:

- Ask the students to uncover their landforms and compare their profiles for accuracy.
- Elicit what difficulties they encountered in this exercise. Ask why sonar is superior to the weighted rope.

STUDENT LABORATORY WORKSHEET

NAME: __________ **CLASS:** __________ **DATE:** __________ **LAB GROUP:** __________

PROBLEM: How can we obtain a profile of the bottom of the carton?

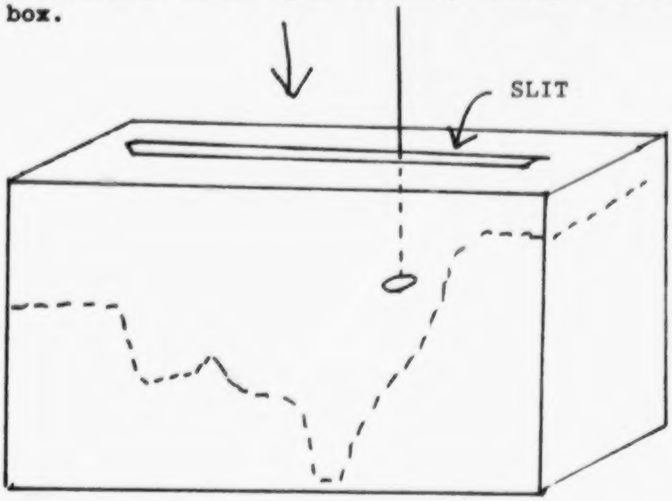
HYPOTHESIS: ____

____

MATERIALS: large cardboard box (with cover), string, fishing weight, meterstick, landforms, masking tape

PROCEDURE:

- Each lab group will have a large closed cardboard carton whose lid has a narrow opening down the middle. Different "landforms" have been placed at the bottom of the carton.
- With a weighted string, take depth soundings every 3 centimeters along the slit in the box.



- The student taking soundings should be assisted by another student to more accurately measure each sounding. Place masking tape markers along the slit to mark where each sounding should take place. As the soundings are announced, each group should graph their results.
- Compare the graphs to the boxes on the floor and present a copy of the profile you obtained to the rest of the class.
  - What problems did early oceanographers encounter by using this method?
  - What problems might be caused by ocean currents between the surface and the bottom?
  - How do oceanographers obtain a profile of the ocean floor today?

CONCLUSION: ____

____

____

UNIT III

LESSON 4

TOPIC: Ocean water

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D23

PROCESS SKILLS: 1, 2, 3, 4, 5, 6, 7, 9, 14

AIM: Why are the oceans salty?

MATERIALS:

- large map of the world

Per lab group:
- 100mL hot water
- 100mL refrigerated water
- two 250mL beakers
- graduated cylinder
- salt
- reagent scoop
- stirring rod

PERFORMANCE OBJECTIVES: Students will be able to:

- list the names of the ocean regions.
- describe the ocean as a continuous body of water divided by geographers into regions.
- describe how salt became concentrated in ocean water.
- describe the composition of seawater.
- identify possible origins of seawater.

MOTIVATION:

- Produce a large map of the world and ask a student to come to the front of the room to name the oceans of the world.

- Elicit how the water in the oceans is different from that found in lakes, rivers, and streams.

- Ask why the ocean waters are salty and lakes are not. Entertain all theories that are provided by the students and list them on the chalkboard.

PROBLEM: Why are lakes, rivers, and streams composed of fresh water and the oceans composed of salt water?

AIM: Why are the oceans salty?

DEVELOPMENTAL STRATEGIES:

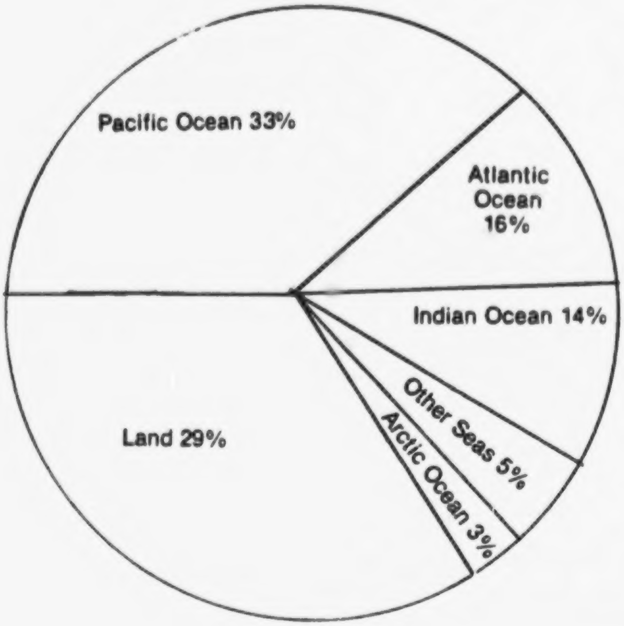
- Place the data table below on the chalkboard:

Ocean	Area (millions of Km)	Volume (millions of Km)	Depth (Km)
Pacific	180	715	4.0
Atlantic	94	337	3.5
Indian	75	284	3.8
Arctic	12	14	1.0

. Elicit answers to the following questions:

- Which ocean contains the greatest amount of water?
- Which ocean covers the greatest surface area?
- How many times larger is the volume of the Pacific Ocean than the Atlantic Ocean? than the Indian?
- Which ocean is the shallowest? the deepest?

. If time permits place the pie graph below on the chalkboard. Discuss the percentage of the earth's surface that is covered by the oceans and by land.



. Elicit answers to the following questions:

- Which ocean covers the most area?
- Which ocean covers the least area?
- How does the Pacific Ocean compare with the landmass?
- Which two oceans are the closest in size?
- Compare the pie graph to the data chart in terms of volume and surface area covered. Do the two show stable relationships between surface area and volume?

- Generate as much discussion as possible on these two visual aids. Be sure to have a large map of the world available during the discussion so that the geographic dimensions being discussed can be reinforced with a visual representation of the oceans.

- After discussion of the chart and graph, direct the discussion from the geographic to the physical composition. Ask how the water at a beach differs from water in a lake. (It contains salt.)

- Elicit ideas on what percentage of ocean water is salt.

- Present the students with the data chart below and discuss the various percentages of salts in ocean water.

ELEMENT or COMPOUND	FORMULA	PERCENTAGE
sodium chloride	$NaCl$	2.72%
magnesium chloride	$MgCl_2$	0.38%
magnesium sulfate	$MgSO_4$	0.17%
calcium sulfate	$CaSO_4$	0.13%
potassium sulfate	K_2SO_4	0.09%
calcium carbonate	$CaCO_3$	0.01%
magnesium bromide	$MgBr_2$	0.01%

- Elicit answers to the following questions:
  - How can we tell the ocean is salty without this chart? (By tasting it.)
  - How can we tell it is mostly sodium chloride? (We can taste it.)
  - Where did all these salts originally come from? (From the bottom sediments and from salt deposits beneath the sea.)

- Refer to a text or present orally the current theories about the origins of salts in sea water. The salts come from minerals of the land washed down by rivers; salts also flow in solution from hydrothermal vents along the mid-ocean ridges. Mention that it is estimated that all the oceans' water circulates through these hot springs every 8 to 12 million years.

- Ask students if they know where the water on earth comes from. After a brief discussion of the students' theories, indicate that earth scientists generally conclude that the earth's waters were outgassed as water vapor during volcanic activity early in the earth's development. Kilauea volcano in Hawaii emits 67% of the gases by volume as water vapor, while Mt. Katmai emits 99% water vapor. Though the water content varies with each volcano, water is the most common constituent.

SUMMARY:

- 75% of the earth's surface is covered by water.

- All the oceans of the world are connected.

- The four major oceans are: Atlantic, Pacific, Indian, and Arctic.

- The largest ocean in the world is the Pacific Ocean.

- Ocean water is composed of approximately 96.5% water and 3.5% salt.

- Sodium chloride (table salt) is a major component of ocean water.

- The salts in salt water come from two sources: minerals are washed into oceans by rivers, and ocean water is flushed through vents on the ocean bottom.

- The earth's waters are believed to have been originally outgassed from volcanoes when the earth was first formed.

HOMEWORK/ENRICHMENT:

- Name the major oceans of the world.

- What percentage of ocean water is composed of dissolved salts?

- Name the most abundant salt found in the world's oceans.

- Name the two possible sources of the salt in the world's oceans.

- Why do bubbles form on the sides of a glass of water that has been left standing for several hours?

- Should some oceans have a higher average temperature than others? Be sure to include the names of oceans and/or areas of oceans that may be warm or cold and explain why.

- Explain why ocean water near the poles is less salty than the ocean water near the equator.

- Explain where earth scientists believe ocean water originated.

- The oceans are salty. Why are lakes and rivers composed of fresh water?

- Design an apparatus that can separate salt from the water. Use diagrams.

- Compare the data from the Atlantic Ocean with that of the Pacific Ocean.

- Collect a liter of sea water and bring it to class for analysis.

- Write a one-page report on hydrothermal vents found along the mid-ocean ridges.

- Write a report on the Great Salt Lake of Utah. Discuss how it became salty.

- Write a report on the Dead Sea in Israel.

UNIT III
Lesson 4

STUDENT LABORATORY WORKSHEET
(Page 1 of 2)

Name____________________ Class__________ Date __________LAB. Group ___________

PROBLEM: What is the relationship between salinity and water temperature?

HYPOTHESIS: Ocean water in tropical regions is more salty than ocean water in arctic regions.

MATERIALS: 100mL each hot and refrigerated water, graduated cylinder, salt, two 250mL beakers, reagent scoop, stirring rod

PROCEDURE:

. Pour 100mL of refrigerated water into one of the 250mL beakers.

. Add one reagent scoop of salt and stir until the salt dissolves; repeat until no more salt dissolves (salt crystals collect begin to collect on the bottom of the beaker). Record the number of scoops dissolved.

. Repeat the procedure using 100mL of hot tap water.

. Prepare a data table to display your results.

QUESTIONS:

In which beaker did more salt dissolve? Why?_________________________________

____

Was the salt water prepared in this investigation the same as ocean water? How or why not?____

____

Examine the chart below:

Ocean Basin	Salinity (0/000*)
Pacific	34.6
Atlantic	35.0
Indian	34.8
Average World Oceans	34.7

*0/000 means parts per thousand.

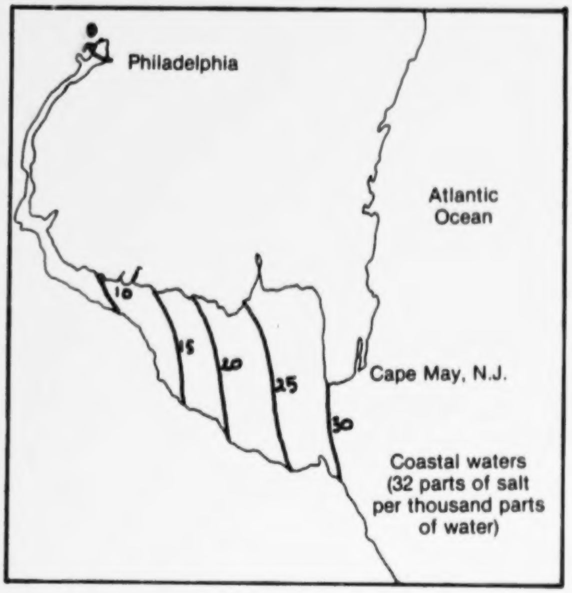
Why is there a difference in ocean salinity from one ocean to the next?________

____

____

____

Examine the diagrams of Cape May, NJ.


Philadelphia
Atlantic Ocean
10
15
20
25
30
Cape May, N.J.
Coastal waters (32 parts of salt per thousand parts of water)

Delaware Bay estuary was created when rising sea level allowed sea water to flood the mouth of the Delaware River. The mixing of river water and sea water forms a salinity gradient that spans 145 Km (90 mi.), from Philadelphia to the Atlantic Ocean. Approximate salinities are shown as parts per thousand (0/000).

Explain why water salinity decreases as you approach Philadelphia.

CONCLUSIONS: Was your hypothesis correct? (Yes/No)__________ Explain:

LESSON 5

TOPIC: Sea water in motion

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D52

PROCESS SKILLS: 1, 2, 9, 10, 14, 17

AIM: How are waves formed?

MATERIALS:

- basin of water
- trough
- stream table, if available
- cork
- straw or hair dryer, if available
- mixture of sand and pebbles

PERFORMANCE OBJECTIVES: Students will be able to:

- identify the most common causes of waves.
- describe the parts of a wave.
- describe the effects of waves on a beach.

MOTIVATION:

- Present a basin of water and have a student blow air softly at the water with the straw (or use a hair dryer). Ask students to observe the effects of moving air on water. Ask what causes waves and why some waves at the beach are larger than others.

PROBLEM: What causes differences in wave heights?

AIM: How are waves formed?

DEVELOPMENTAL STRATEGIES:

- Draw two diagrams on the chalkboard similar to the ones below and go over (or review) the various components of a wave.

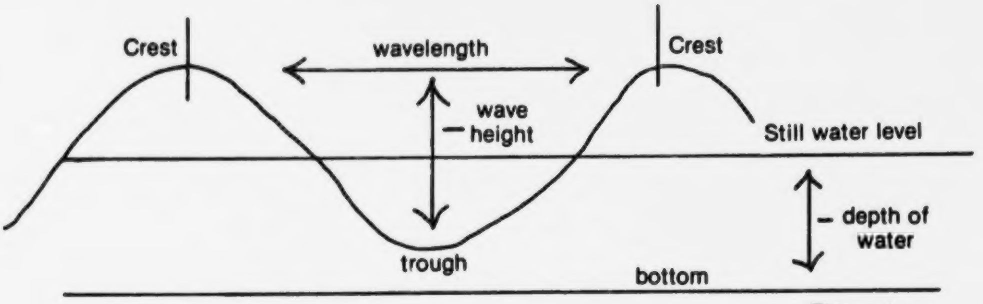


Figure A

223

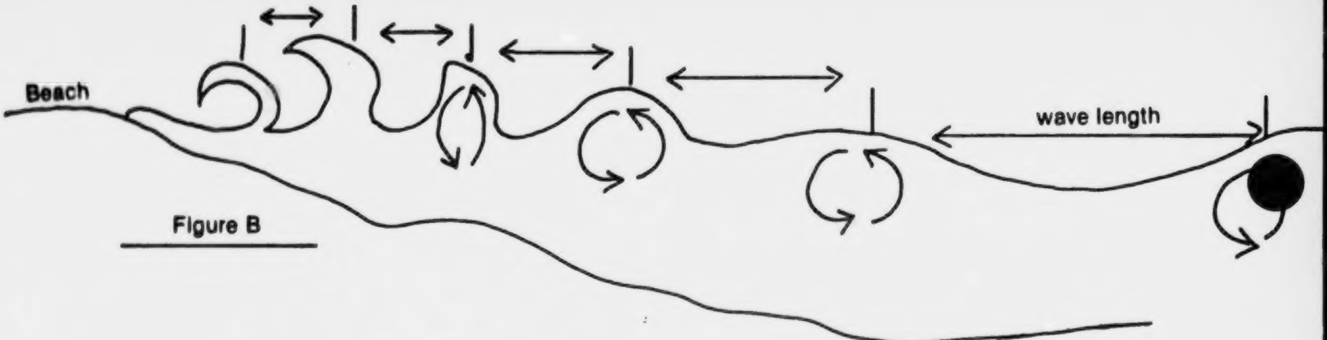


Figure B

- Prompt students to describe their experiences at the beach and to relate them to the diagrams.

- Discuss with students why the wavelengths become shorter as waves reach the shore. (The frequency of water waves remains constant; however, speed changes. Waves travel faster in deeper water and slower in shallower water. According to the formula V = wf [velocity = wavelength X frequency], when speed decreases, wavelength must also decrease.)

- Ask students why the crests become taller as they come closer to the shore. (The distance to the sea floor becomes less, causing the wavelength to shorten, which pushes the waves up in the water.)

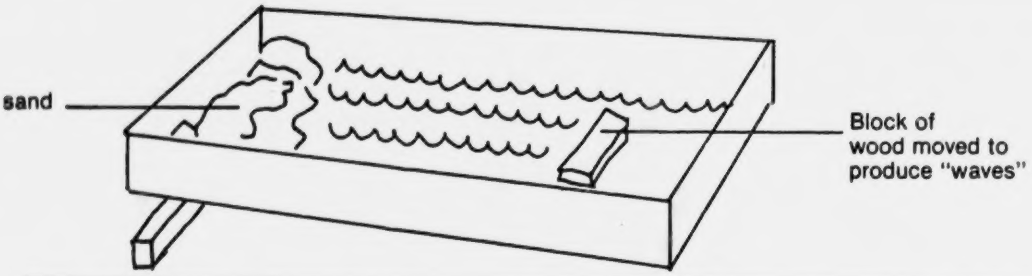
- Elicit what causes the breakers that form whitecaps near the shore. (The waves become unstable as the water becomes shallower, until they finally break.)

- Ask students if waves move objects in the water. After a brief discussion and statement of opinions, demonstrate the effects of waves on floating objects by placing a cork in a basin of water and dropping a pebble into the basin. Ask if the cork followed the waves. (It does not follow the waves but moves up and down.) Repeat the demonstration several times until all students have observed it.

- The students may doubt that an object does not move with the waves because they may have experienced the power of waves pushing them ashore at the beach. Remind students that the up and down motion occurs only in deep water and that their experience at the beach is in shallow water.

- Elicit effects powerful waves have on the beach. Discuss various opinions and present the following demonstration:

  - Provide a shallow trough of water with sand and pebbles piled at one end to simulate a beach. Move a block of wood up and down at one end of the trough to simulate waves. The students should determine what occurs from their observations. Be sure to discuss undertow and longshore or littoral drift.



- **Ask why some waves encountered at the beach are larger than others. (The harder the winds blow, the larger the waves. Larger waves are swells formed by storms in the open sea.** Also describe how the fetch [distance the wave **travels**] and the length of time the wind blows affect the size of a wave. Indicate that waves may travel thousands of miles before reaching shore.)

SUMMARY:

- Most waves are caused by wind.
- The factors that affect the size of waves are speed of wind, fetch (distance over which the wave travels), and the length of time the wind blows.
- The wavelength is the distance between the wave crests.
- The wave height is the distance between the trough and the crest.
- Waves break on the beach because the distance to the bottom decreases, causing the wavelength to shorten and eventually break.
- After a wave breaks on the beach, the water returns to the sea by moving under the next wave. This outward flow of water is called the undertow.
- In the open sea, the particles of water do not move forward. They simply move in a circular motion. The wave energy passes through the water.
- Waves that strike the beach at an angle produce a current that runs along the shore and is called the longshore current.

HOMEWORK:

- List three factors that determine the size of a wave.
- Draw a diagram of a wave and label its parts.
- Explain why waves rise up and break along the beach.
- What is undertow?
- If you fall overboard a half-mile from shore, will the waves eventually pull you ashore?

ENRICHMENT:

- Prepare a report on the differences among wind-formed waves, tidal waves, and tsunamis.
- Explain why beaches are larger in the summer than they are in the winter.
- Explain why the sand at some beaches must be replaced every few years.
- Explain the difference between a ripple and a wave.

UNIT III

LESSON 6

TOPIC: Beach/sea cliff terrace formation--erosive action

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D

PROCESS SKILLS: 1, 2, 14, 15, 17

AIM: What happens at the land-sea interface?

MATERIALS:

- pictures of beaches from all over the world
- diagram or map of common shoreline features
- Reference Sheets 1, 2, and 3

PERFORMANCE OBJECTIVES: Students will be able to:

- explain how wave action erodes the land by removing loose material.
- list the different currents that produce the shoreline.
- describe the variables that affect the erosive power of waves.
- list the different formations that are produced by wave action.

MOTIVATION:

- Prior to the lesson, have students collect pictures of seaside resorts or beach areas as a basis for discussion of typical land-sea interfaces.

- Ask students to describe different beaches they have been to or that they have seen on TV, etc. Discuss beach materials at different locations (examples: New York, white sand beaches; Hawaii, black sand beaches; Bermuda, pink coral beaches).

PROBLEM: How are the different formations formed at the seashore?

AIM: What happens at the land-sea interface?

DEVELOPMENTAL STRATEGIES:

- Pose the question, "What effects can a wave have when it hits the shore?" Expect such answers as: break up the land, remove the sand, leave behind a rock shore, shape the coast, etc.

- Elicit that the wave's erosive power is increased by the material it carries. The strength of the wave is related to the size of the particles and the load (volume of material) it carries.

- Discuss sea cliffs, sea caves, and sea stacks as weaker shore areas that waves have eroded.

- Display a diagram or map that illustrates some common shoreline features such as a beach, spit, bay barrier, and barrier island. Discuss the origin of these features (erosion and then deposition by waves).

- Ask students why beaches aren't permanent geological features. (Wind, waves, and currents are constantly trying to move sand. Beach drifting, for example, is caused by longshore currents.) We can create barriers to alter beach erosion.

- Ask students if they have ever felt very strong currents while they were standing at the beach. Identify these as rip currents.

- Utilize Reference Sheets 1, 2, and 3 as a basis for discussion. They may be reproduced and distributed or presented on the overhead projector.

SUMMARY:

- Waves can erode the land in different ways.

- The erosive power of a wave can be increased by the amount and size of material it carries.

- Some depositional features produced by waves are beaches, spits, bay barriers, and barrier islands.

- Sea cliffs, sea caves, and sea stacks are erosive features produced by waves.

- Longshore currents are caused by wave action in the nearshore zone.

- Rip currents are caused by water buildup due to the water's shoreward movement.

HOMEWORK:

- Explain why we want to reduce wave erosion at the shoreline.

- How do waves cause erosion?

- Relate the strength of a wave to the size of the material it carries and its load.

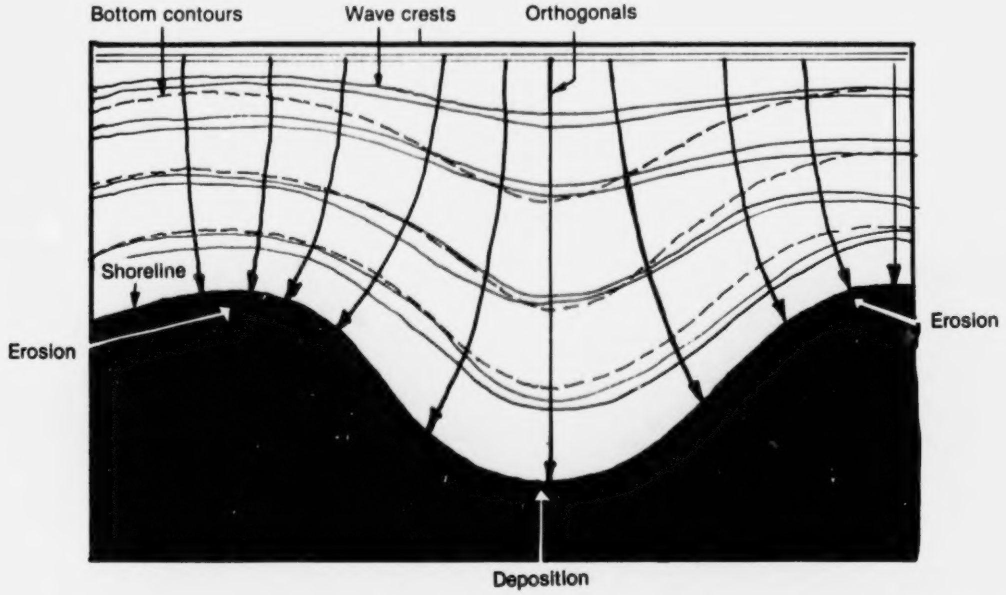
- Name four wave deposits.

- Describe two types of nearshore currents.

ENRICHMENT:

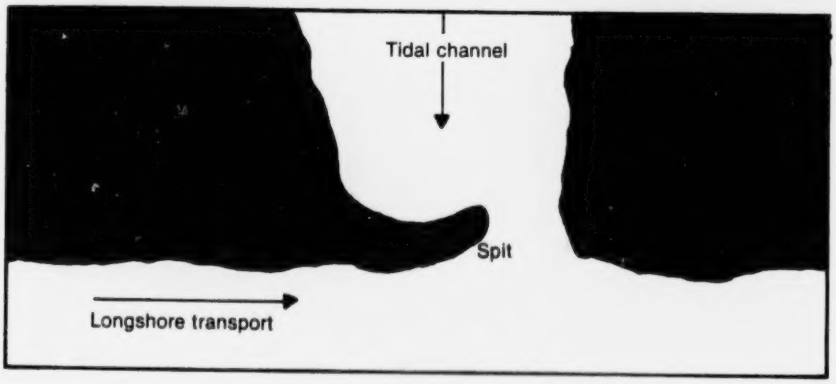
- Collect and display beach sand from as many places as you can.

A


Bottom contours
Wave crests
Orthogonals
Shoreline
Erosion
Erosion
Deposition

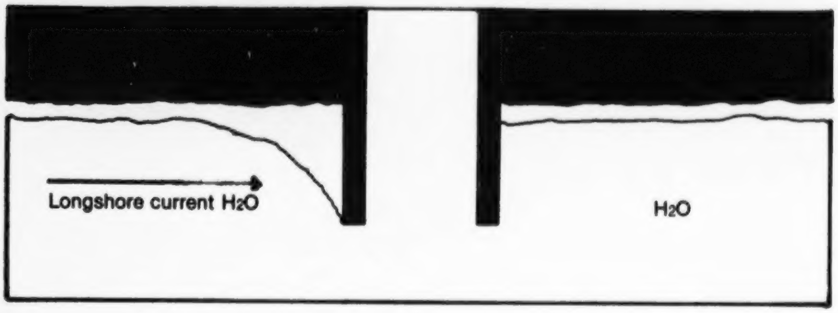
Wave refraction pattern for irregular shoreline with uniformly sloping bottom.

B


Tidal channel
Spit
Longshore transport

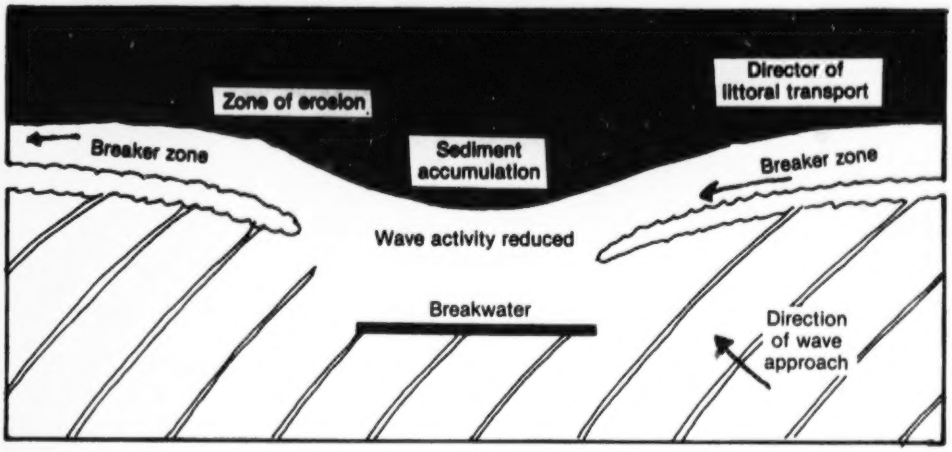
Spit development as the result of interruption of longshore currents.

C


Longshore current H2O
H2O

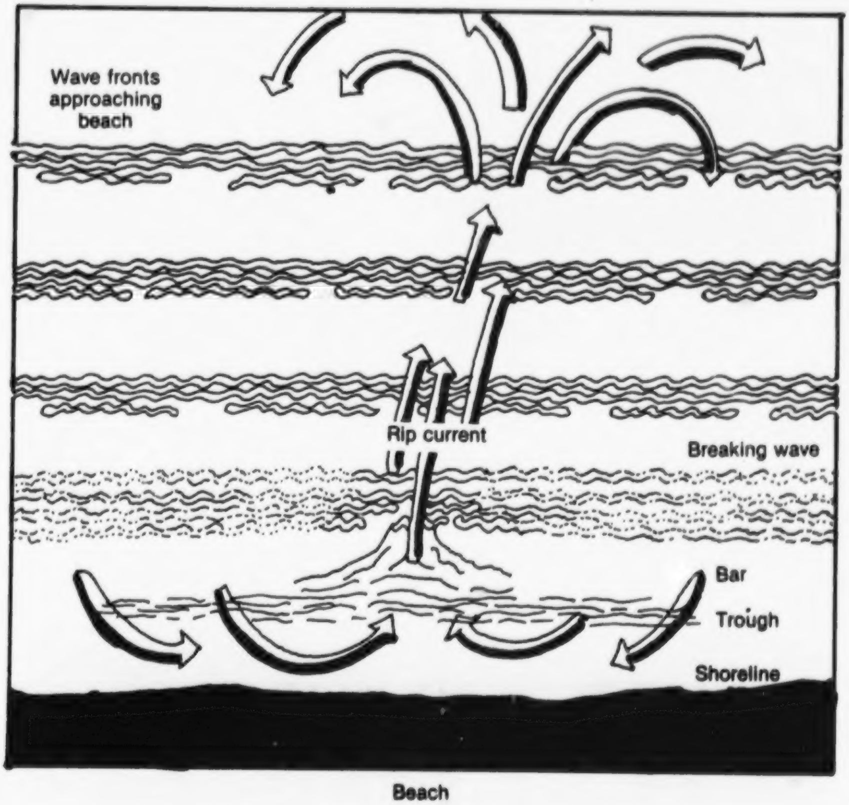
Sediment accumulation behind a breakwater due to the interruption of littoral sediment transport. The breakwater prevents waves from entering shallow water; thus, no significant longshore currents are present behind the breakwater.

D


Zone of erosion
Director of littoral transport
Breaker zone
Sediment accumulation
Breaker zone
Wave activity reduced
Breakwater
Direction of wave approach

Sediment build-up behind jetty which acts like a dam to longshore transport of sediment.

E


Wave fronts approaching beach
Rip current
Breaking wave
Bar
Trough
Shoreline
Beach

Rip currents commonly form where there is a path of low resistance, such as a topographic low in the nearshore sandbars. This type of current is probably what is experienced by those who claim to be caught by "undertow."

LESSON 7

TOPIC: Currents

STATE BLOCK REFERENCE/CORE UNDERSTANDING: D21

PROCESS SKILLS: 1, 2, 4, 6, 9, 11, 14, 15

AIM: What causes the movements of ocean currents?

MATERIALS:

For the teacher:
- battery jar
- congo red or vegetable dye
- water
- maps of the world
- Erlenmeyer flask (250-500 mL)
- two-hole rubber stopper containing unevenly placed glass tubing
- yellow and blue construction paper
- cellophane tape

Per lab group:
- a clear plastic shoebox or small aquarium
- large jar or beaker
- soil
- sea water
- food coloring

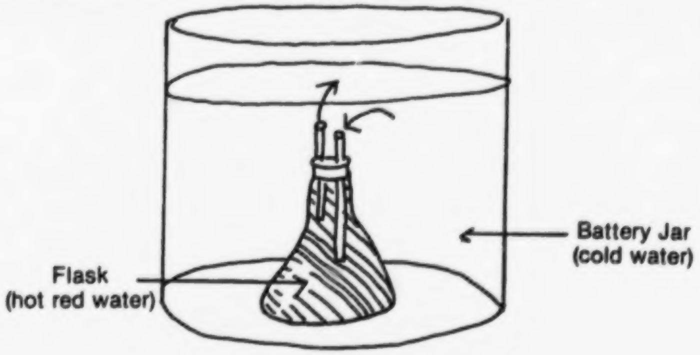
PERFORMANCE OBJECTIVES: Students will be able to:

- describe different kinds of ocean movements.
- describe the effects of density difference on ocean water.
- explain the causes of surface current movements.

MOTIVATION:

- Elicit what would happen if a message were placed in a bottle and dropped somewhere in the ocean.

- Fill a battery jar with cold water. Add hot water and a few drops of congo red to the Erlenmeyer flask. Stopper the flask with the two-hole stopper containing unevenly placed glass tubing. Place the flask in the battery jar. Have students record all of their observations.



. Elicit answers to the following questions:

- What happened to the red water? (It rose out of the flask.)

- Why? (It is hotter and therefore less dense than the cold water in the jar. The denser cold water sank through one of the tubes in the rubber stopper and pushed the hot, red-dyed water up and out of the other tube.)

- Why does the red water remain at the top of the bell jar? (Because it is less dense.)

. Place a light object (crumpled piece of paper, cork, etc.) in the battery jar.

- Why does this object float? (It is less dense than the water.)

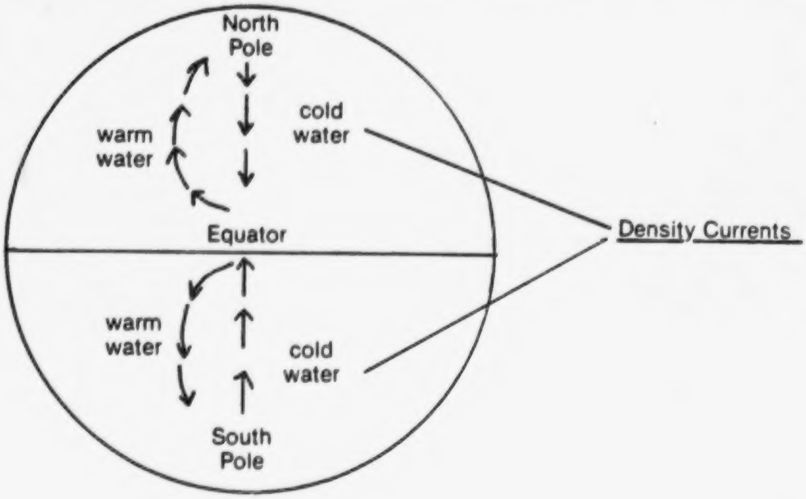
- How does this demonstration relate to ocean currents? (Warm water is pushed to the surface of the ocean and cold water remains at the bottom.)

PROBLEM: What would happen if you placed a message in a bottle and dropped it somewhere in the ocean?

AIM: What causes the movements of ocean currents?

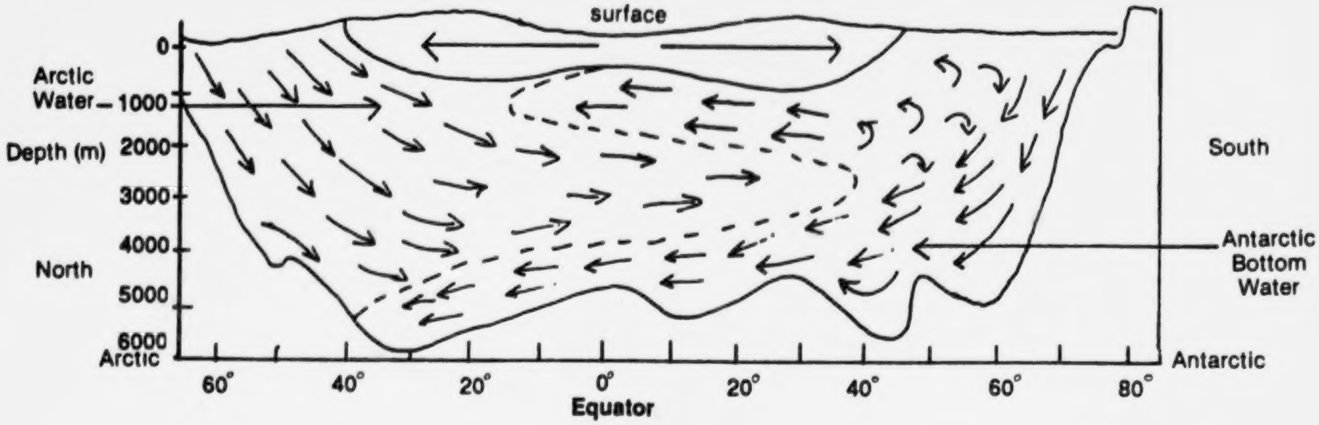
DEVELOPMENTAL STRATEGIES:

. Place the diagram below on the chalkboard and ask how the previous demonstration helps explain the existence of ocean currents. Remind students that the previous demonstration has already established that cold, dense water is pushed downward and warm, less dense water is pushed upward.



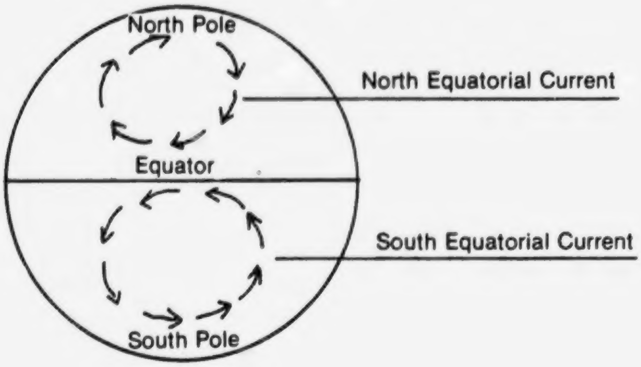
. Ask students where the warmest water is located on this diagram. (At the equator.) the coldest? (At the poles.)

. Indicate that the wind and the rotation of the earth moves equatorial water toward the poles, where cold water sinks, and returns back to the equator via the ocean depths. This is called a density current. Density currents help distribute heat from the equator surface to the polar regions.


surface
0
Arctic Water
1000
Depth (m)
2000
3000
4000
North
5000
6000
Arctic
South
Antarctic Bottom Water
Antarctic
60°
40°
20°
0°
Equator
20°
40°
60°
80°

- If students have difficulty understanding density currents, use a wall map to explain how the Gulf Stream or North Equatorial current moderates the weather in the northeastern United States and England. (To reinforce this concept, you may wish to analyze some diagrams or charts in the text or have students research the causes and effects of density currents.)

- Indicate that in addition to these density currents, there are surface currents that are propelled by the wind and curved by the rotation of the earth.


North Pole
North Equatorial Current
Equator
South Equatorial Current
South Pole

- Ask students if they know the name of the surface current that comes nearest New York City (the Gulf Stream).

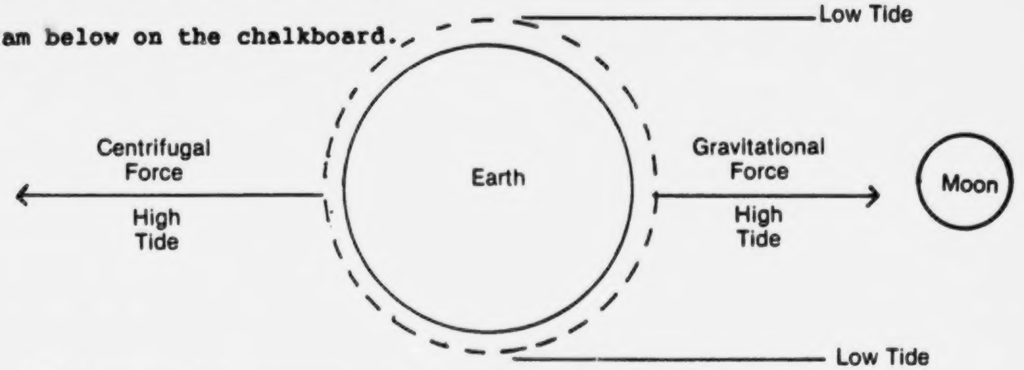
- Display a Mercator projection map of the world and show the areas of the Atlantic and Pacific where these currents are found.

- Discuss with students how these surface currents affect climate. (They keep northern latitude cities and countries warmer than they would ordinarily be during winter and cooler than they would ordinarily be during summer.)

- If students have difficulty grasping the idea that countries like Norway and England have much warmer winters than Labrador and Greenland, which are at almost the same latitude, review that the Gulf Stream is a warm water current that brings heat from the equator to northern latitudes.

- Ask students to recall trips to the beach when the amount of visible beach increased or decreased as the day passed. Elicit what causes this movement of water (tides). (The moon.) How does the moon do this when it is so distant? (The gravitational attraction of the moon pulls on the earth as a whole, and on the water on its surface.)

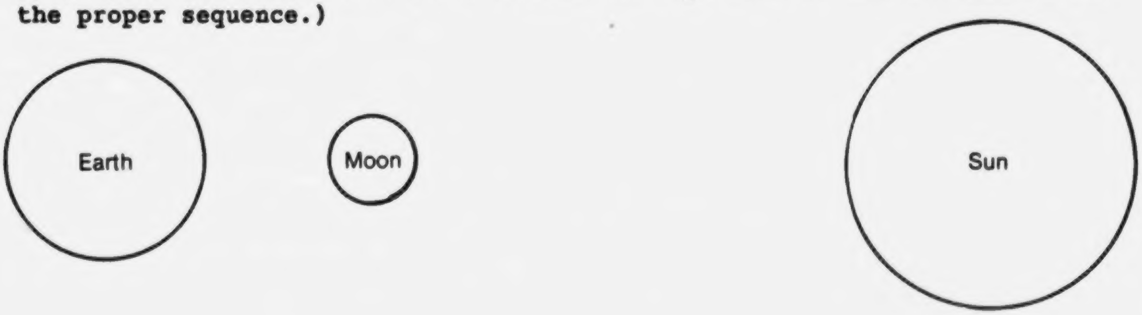
- Draw the diagram below on the chalkboard.



- The moon's apparent revolution around the earth takes 24 hours and 50 minutes, so high tides occur every 12 hours and 25 minutes.

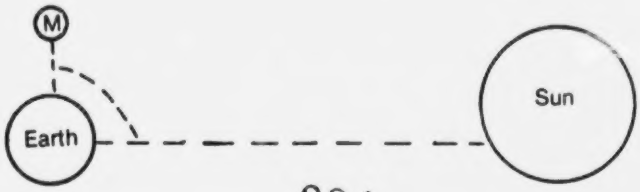
  - What other celestial body might also be responsible for tides? (The sun.)

  - What positions of the moon, sun, and earth would produce the highest tidal range? (Use three different colors of construction paper to symbolize sun, moon, and earth, and ask a student to tape them to the chalkboard in the proper sequence.)



- Indicate that this alignment occurs twice a month and that the resulting tides are called spring tides.

  - What position of the sun, moon, and earth would produce the smallest tidal range?



- Have several students experiment with the construction paper until the proper alignment is achieved. Tidal forces are minimal when the sun and moon are at right angles. Tides that result because of this alignment are called neap tides.

SUMMARY:

- Cold water is more dense than warm water.
- Warm water is pushed above cold water because it is less dense.
- The circulation of deep sea water and surface water is called a density current.
- Cold water sinks at the poles and rises near the equator.
- Movements of water near the surface of the oceans are called surface or wind-driven currents.
- Surface currents are powered by winds and curved by the rotation of the earth.
- Surface currents bring warm equatorial water to northern latitudes, making them warmer in the winter.
- A warm water current near New York City is called the Gulf Stream.

HOMEWORK:

- Why did the red water rise to the top of the battery jar?
- Explain why cold water is more dense than warm water.
- Name two types of water movements discussed in class today.
- Explain why all water currents are curved.
- What is the directon of all wind-driven currents in the northern hemisphere? in the southern hemisphere?
- Explain how warm water currents can affect the climate of a region.

ENRICHMENT:

- List all the warm and cold water currents found in the world.
- At home, make a diagram of a density current. Chill a small container of salt water in the refigerator and add two drops of food coloring to it. Warm another container of salt water. Pour the chilled salt water into it. The food coloring will enable you to see the chilled salt water as it flows under the warm salt water. Explain why this occurs.

UNIT III
Lesson 7

TEACHER LABORATORY WORKSHEET
(Page 1 of 2)

INTRODUCTION:

- Density currents can occur because of differences in the density of two fluids or from varying amounts of material contained in a solution or a suspension. Currents that arise from varying amounts of material contained in a solution or a suspension are called turbidity currents.

- Turbidity currents generally occur after a large mass of sediment is rapidly deposited, e.g., river delta. When a sediment mass becomes unstable, unites with water, and forms a turbidity current, it combines with water and becomes more dense than the surrounding water. This may be caused by an earthquake or a hurricane; however, most turbidity currents arise from a constant source of sediment.

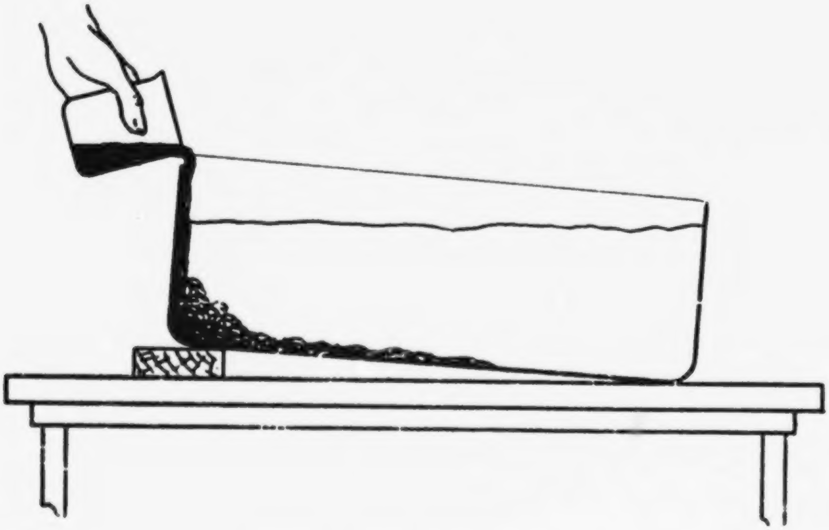
PROBLEM: When a hurricane approaches a coastal area, large amounts of sediment are moved from the beach. This is sometimes associated with the breaking of communications cables on the continental slope. What relationship exists between the movement of large amounts of sediment and the breaking of communications cable?

HYPOTHESIS: The sediment that is transported from the beach causes the cables to snap.

MATERIALS: clear plastic shoeboxes or small aquariums, large jars or beakers, soil, sea water, food coloring.

PROCEDURE:

- Place a clear plastic shoebox (or aquarium) on a table and elevate one end about 5cm.
- Pour tap water into the shoebox until it is about 2/3 full.
- Add several drops of food coloring to a container of sea water and mix.
- Slowly pour the colored sea water into the shoebox of tap water (see figure) so that it flows down the inside of the box at the elevated end. Watch how it flows along the bottom of the box, moving as a density current. Be sure you observe the current from the side of the box so that the lighter tap water above the heavier sea water is clearly visible.
- To produce a turbidity current, place the shoebox on the table as before. This time add sea water until the box is about 2/3 full. This will represent a still body of salty water like the ocean.
- Now add several handfuls of fine dirt to a container of tap water and mix thoroughly. This will represent a muddy river entering the ocean.
- Slowly pour the muddy water into the shoebox, allowing it to flow down inside of the box as before. Observe a turbidity current flowing under sea water.



CONCLUSIONS:

- Temperature and suspended or dissolved solids are the controlling factors in density currents. The communications cables snap during hurricanes because they cause movement of sediment from the beach to the continental slope. These disturbances can break cables.

UNIT III
Lesson 7

STUDENT LABORATORY WORKSHEET

NAME ____________________________ CLASS ________ DATE __________ LAB GROUP # ______

PROBLEM: When a hurricane approaches a coastal area, large amounts of sediment are moved from the beach. This is sometimes associated with the breaking of communications cables on the continental slope. What relationship exists between the movement of large amounts of sediment and the breaking of communications cable?

HYPOTHESIS: ____

____

MATERIALS: clear plastic shoebox or small aquarium, large jar or beaker, soil, sea water, food coloring

PROCEDURE:

- Place a clear plastic shoebox (or aquarium) on a table and elevate one end about 5 cm.
- Pour tap water into the shoebox until it is about 2/3 full.
- Add several drops of food coloring to a container of sea water and mix.
- Slowly pour the colored sea water into the shoebox of tap water so that it flows down the inside of the box at the elevated end. Watch how it flows along the bottom of the box, moving as a density current. Be sure you observe the current from the side of the box so that the lighter tap water above the heavier sea water is clearly visible.
- To produce a turbidity current, place the shoebox on the table as before. This time add sea water until the box is about 2/3 full. This will represent a still body of salty water like the ocean.
- Now add several handfuls of fine dirt to a container of tap water and mix thoroughly. This will represent a muddy river entering the ocean.
- Slowly pour the muddy water into the shoebox, allowing it to flow down inside of the box as before. Observe a turbidity current flowing under the sea water.

CONCLUSION: ____

____

____

____

LESSON 8

TOPIC: Oceans as a resource

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: D24

PROCESS SKILLS: 1, 2, 14, 15

AIM: How are the oceans used as a resource?

MATERIALS:

- Mercator projection map
- pictures of sea farms
- pictures of different types of food fish

PERFORMANCE OBJECTIVES: Students will be able to:

- demonstrate how fresh water is recovered from the sea.
- describe the oceans as a food resource.
- describe the oceans in terms of energy resources.
- describe the mineral wealth in the oceans and on or beneath the ocean floors.
- identify the major sources of oceanic pollutants.

MOTIVATION:

- Ask students where they could find an ounce of gold. (One possibility is to extract it from 20,000 tons of sea water. However, 700 tons of other solids would be left over, and we do not have the technology that would make the process cost-effective at the present time.)

PROBLEM: What are some of the other ways the oceans are used as a resource?

AIM: How are the oceans used as a resource?

DEVELOPMENTAL STRATEGIES:

- Ask students to formulate a model for extracting fresh water from the sea. Answers should include boiling, solar evaporation, and using a plastic membrane that allows only pure water to pass through.

- Explain that, at present, only table salt, bromides, and magnesium are recovered from the sea. Other valuable minerals are known to occur on the ocean floor or below it, but mining them requires special methods that are in need of improvement.

- Take a poll. Ask students how many of them eat fish or other seafood and if they buy or catch it. Elicit that fish are the most abundant form of food taken from the sea. Sea farming (mariculture) is increasing our production of seafood. Still, only about 10 percent of the world's food comes from the sea.

. Elicit how energy can be taken from the ocean. (Energy can be obtained from the oil and gas below the sea floor; heat from the sun is stored in the ocean; waves and currents also possess energy, as do the plants that grow in the sea. Water from the oceans may also power nuclear plants in the future.)

. Ask students to list four ways that people contribute to ocean pollution. Discuss their answers. Obtain pictures from books on oceanography from your local public library. Slides, film strips, and photographs are also very helpful.

SUMMARY:

. Desalination is the process of recovering fresh water from the sea.

. Table salt, bromides, and magnesium are currently extracted from sea water.

. Only about 10 percent of the world's food supply comes from the sea.

. Oceans are an energy resource.

. Humans have contributed to the pollution of the oceans.

HOMEWORK:

- What are two resources other than food that can be taken from the sea?
- Identify several major problems that prevent the development of ocean resources.
- Explain why the oceans are an energy resource.
- Explain why certain parts of the ocean produce more fish than others.

ENRICHMENT:

- Write a report on the ways we are polluting the oceans.

UNIT IV

LESSON 1

TOPIC: Weather

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E1

PROCESS SKILLS: 1, 2, 3, 12

AIM: What is meant by the term weather?

MATERIALS:

Duplicate for distribution:
- local weather maps for the past three days
- weather forecast from a newspaper
- Student Worksheet

PERFORMANCE OBJECTIVES: Students will be able to:

- define the term weather.
- explain the information available on a weather map.
- create a chart or table that records weather data.
- appraise the accuracy of a weather forecast.

MOTIVATION:

- Distribute weather maps for the past three days to each student. Have them compare and contrast each map and predict the weather for the following day.

PROBLEM: What information do we need to know in order to understand weather?

AIM: What is meant by the term weather?

DEVELOPMENTAL STRATEGIES:

- Using the weather map, challenge the students to define the term weather. (Weather is the condition of the the atmosphere over short periods of time.)

- Elicit that the following atmospheric conditions constitute the weather: air temperature, air pressure, wind direction, wind speed, precipitation, sky condition, and humidity.

- Distribute a copy of a weather map and the Student Worksheet (a weather factors data chart) to each student. Have them, working individually or in groups of two, examine the weather map and fill in the first column on their worksheet. (The data chart will make it easier to graph results.)

- Have the students determine the accuracy of yesterday's newspaper forecast. (Weather information for N.Y.C. can be obtained by dialing 212-976-1212 or 212-315-2715.)

- Ask students what other information the weather map provides. Elicit that weather maps use symbols to show high and low pressure areas, and various types of fronts. These factors help meteorologists to forecast future weather.

SUMMARY:

- Weather deals with the short-term variations of the atmosphere.

- Weather is generally dominated by broad-scale weather systems which are symbolically depicted on surface weather maps and which can be described by models.

HOMEWORK:

- What is weather?

- Using your Student Worksheet, record the weather data from a newspaper or other source for one week.

ENRICHMENT:

- Have students set up their own weather station.

  - Record data on weather variables.
  - Announce weather information over the P.A. each morning.

- Have students record the weather forecasts of three radio stations on a chart. The next day record the actual weather. After one week of record-keeping, compare the accuracies of the three stations.

- Have students write a report on the latest technological innovations in the science of meteorology.

	Date							
Air Temperature in °F	80							
	70							
	60							
	50							
	40							
	30							
	20							
	10							
Atmospheric Pressure in mb.	1040							
	1030							
	1020							
	1010							
	1000							
	900							
	Wind direction, speed, and sky cond.							
	Cloud type							
	Weather							
Precip. in inches	0.5							
	0.3							
	0.1							

LESSON 2

TOPIC: Air masses

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E2

PROCESS SKILLS: 1, 2, 9, 13, 17, 20

AIM: How is weather affected by air masses?

MATERIALS:

- map of North America
- thermometers
- ice cubes
- beakers
- tape
- cold sand
- sand at room temperature
- heat lamp
- hot water
- cold water

PERFORMANCE OBJECTIVES: Students will be able to:

- define air mass.
- explain how air masses are formed.
- explain the relationship between an air mass and its source region.
- compare and contrast the properties of various air masses.
- define the terms polar, tropical, continental, and maritime.
- deduce how an approaching air mass might change the weather.

MOTIVATION:

- In front of the room set up four large beakers. Half fill beaker A with cold sand (sand previously placed in a freezer or refrigerator). Half fill beaker B with cold water and ice. Half fill beaker C with hot water and half fill beaker D with sand. Shine a heat lamp directly on the sand of beaker D.

- Show the students four thermometers, all registering room temperature. Record this temperature on the chalkboard. Tape a thermometer to the side of each beaker, making sure that the bulb of the thermometer is near, but not touching, the contents of the beaker. Record the time on the chalkboard.

- Ask the class to look at the map of North America and predict which region each beaker represents.

PROBLEM: What happens to the air above each beaker?

AIM: How is weather affected by air masses?

DEVELOPMENTAL STRATEGIES:

- Elicit predictions about what happens to the air above each beaker.

- Ask the class to help develop a chart that will summarize the information. For example:

Beaker	Contents	Characteristics of Beaker	Temp. After 15 Minutes	Characteristics of Air Above Beaker
A	cold sand	cold, dry		cold, dry
B	cold water	cold, wet		cold, wet
C	hot sand	hot, dry		hot, dry
D	hot water	hot, wet		hot, wet

- Challenge the class to explain why it is colder at the poles than at the equator. (Angle of sun's rays.)

- Air takes on the temperature and moisture characteristics of the region tha it is over. A huge amount of air with uniform temperature and moisture content is called an air mass.

- Introduce the terms polar (cold), tropical (hot), continental (dry), and maritime (wet). Ask students to use these terms to identify characteristics of air masses: beaker A - continental, polar; beaker B - maritime, polar; beaker C - continental, tropical; and beaker D - maritime, tropical.

- Ask the class what would happen to our weather if a new air mass arrived. The class should indicate it would change, and the type of change would depend on the characteristics of the arriving air mass.

- Air masses, because of the rotation of the earth and pressure differences, tend to move from west to east across the contiguous United States.

SUMMARY:

- Weather arises from the unequal distribution of energy in the earth's envelope of air.

- Large bodies of air called air masses determine much of our weather.

- Air masses form when air found over a large, nearly uniform area takes on the temperature and moisture characteristics of that area.

- Air masses transport weather conditions, which change gradually as they move slowly over new areas.

- Air masses can be identified and classified by type according to their source regions, their moisture characteristics, and their temperatures relative to the temperatures of the surfaces over which they are moving.

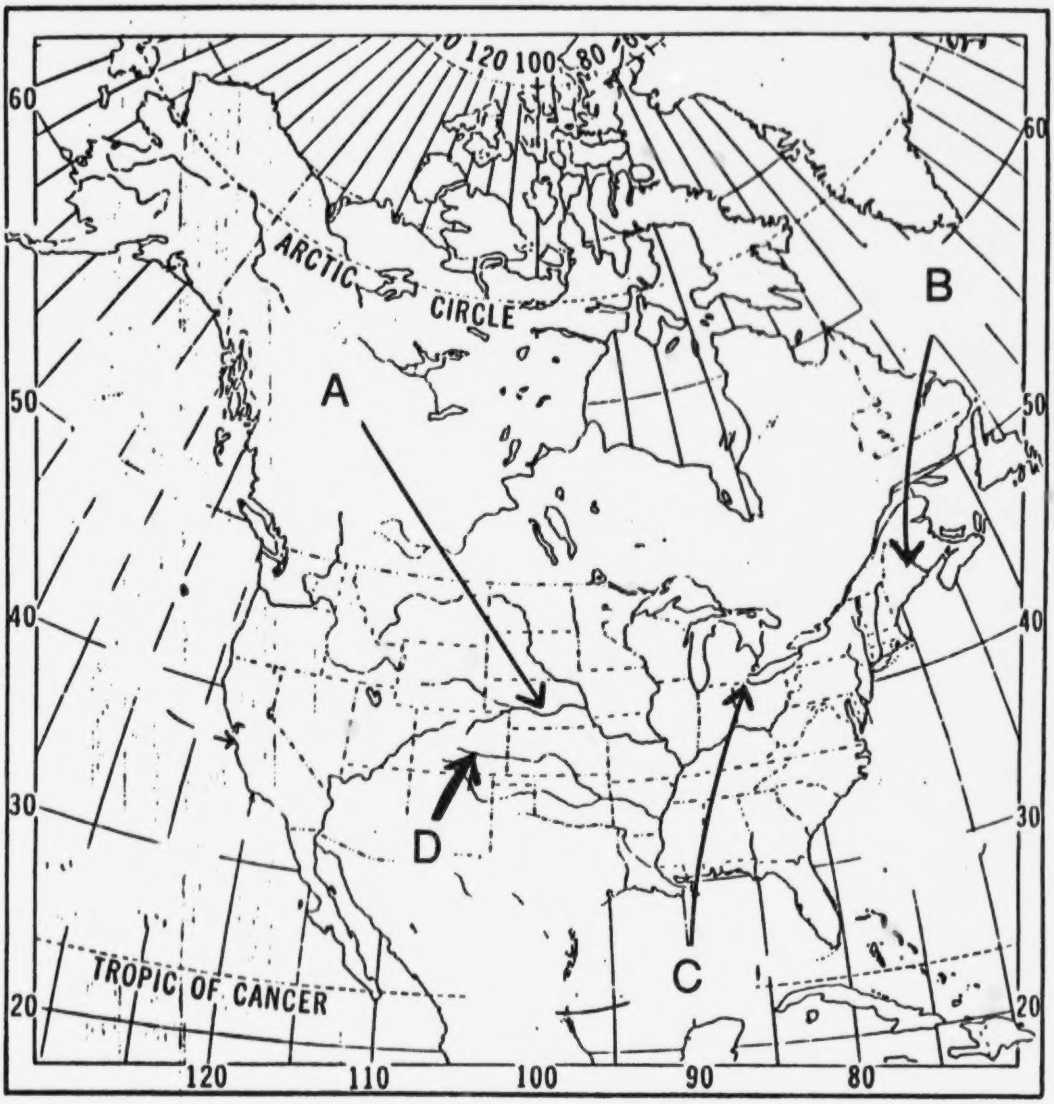
- After migrating from their source regions in higher or lower latitudes, air masses tend to move in an easterly direction over the contiguous United States.

HOMEWORK:

- Distribute copies of the Reference Sheet.
  - Describe the air masses that would form over the lettered regions.
  - Explain how air masses influence weather.
  - Using a newspaper weather map, determine the following:
    - What type of air mass is currently dominating our region?
    - What air mass might be moving into our region?
    - What changes in weather will result from the new air mass?

ENRICHMENT:

- Trace the movements of air masses across the United States for one week.
- Report on the seasonal differences of air masses.


120
100
80
60
60
ARCTIC CIRCLE
A
B
50
50
40
40
30
30
D
C
TROPIC OF CANCER
20
20
120
110
100
90
80

UNIT IV

LESSON 3

TOPIC: Station model

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E/C1

PROCESS SKILLS: 13, 14, 18, 19

AIM: How can we show the weather on a station model?

MATERIALS:

- a large weather map
- Reference Sheet

PERFORMANCE OBJECTIVES: Students will be able to:

- explain the need for the use of the station model.
- demonstrate an understanding of the station model by creating one from data supplied.
- analyze station models to determine the weather conditions at each area.

MOTIVATION:

- If you were a meterologist and had to record on a map all aspects of the weather, what shorthand methods would you devise?

PROBLEM: How can we standardize our weather shorthand recording methods so that everyone will understand them?

AIM: How can we show the weather on a station model?

DEVELOPMENTAL STRATEGIES:

- Display a large weather map and tell students that it contains information from hundreds of cities. Have them realize that meteorologists couldn't possibly write everything on the map, and so a shorthand method of recording weather information was devised.

- Distribute copies of the Reference Sheet (or display it as a transparency).

- Develop a station model for an imaginary set of conditions. Start with the circle representing the city. The more filled in the circle, the cloudier the skies. Clear conditions would be represented by an empty circle.

- Wind is shown blowing toward the city. Ask the class to imagine that the circle is replaced by an arrowhead. Therefore, the directional symbol on the Reference Sheet shows that the wind is blowing from the southwest, and is called a southwest wind. The more feathers on the end of the directional symbol, the harder the wind is blowing.

- Temperature is always recorded in the upper left corner of the station model. On this handout, it is recorded in degrees Fahrenheit. The dew point is recorded in the bottom left corner, also in °F. Note that the dew point is very close to the air temperature in this example, and so precipitation is very likely. Be sure that the class understands this much before continuing.

- Show the class where the barometric pressure is recorded (in the upper right). On this handout, the numbers are coded the way they would appear on a real weather map, but there is no need to explain in detail. Have the students write the entire pressure in the corner.

- The other weather conditions on the station model (visibility, present weather, barometric trend, and precipitation) are not always shown, and can be considered optional. Let your class's interest and ability be the guide as to how far you will go.

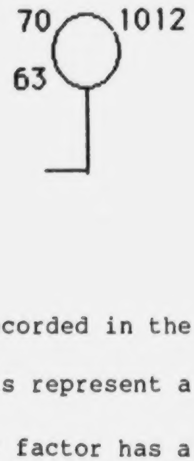
- After it seems that the class understands the reason for the use of the station model--and the mechanics--put the following chart on the board. Have the students design station models for each city:

	Temp(°F)	Dew Point(°F)	Wind Dir	Wind Speed (knots)	Pressure(mb)	Sky
City A	70°	63°	S	10	1012	clear
City B	70°	68°	SW	15	1004	partly cloudy
City C	55°	40°	--	calm	1020	clear

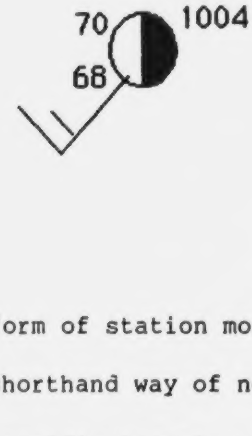
- Ask students to determine in which city it is most likely to rain. (City B, because the dew point is closest to the air temperature as well as because it is cloudy.)

The three station models should look like the drawing below:

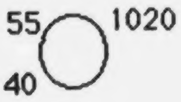
A



B



C



SUMMARY:

- Weather is recorded in the form of station models.

- Station models represent a shorthand way of noting weather conditions.

- Every weather factor has a specific location on a station model.

HOMEWORK:

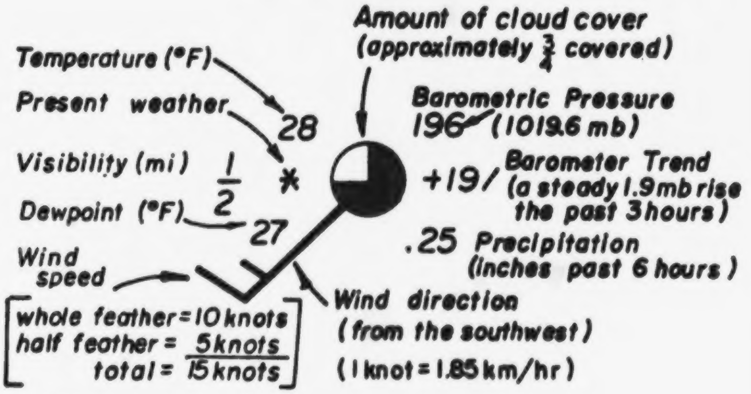
- Listen to today's weather report, and design a station model for it.
- Create three imaginary station models. Bring them to class, and have the other students describe the weather in your three cities.

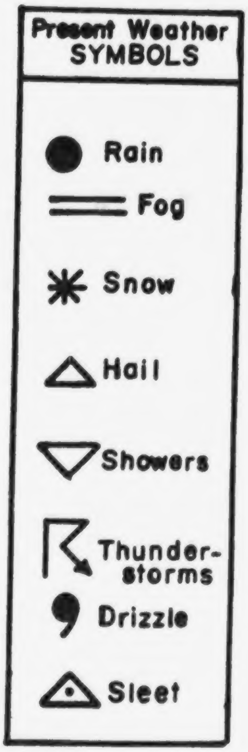
ENRICHMENT:

- Create a weather map for an imaginary country. Have at least 10 station models on the map. Draw in isobars for barometric pressure (the same way you drew countour lines on topographic maps).
- Using the weatherwatch data you are collecting, create a station model for each day.

WEATHER MAP INFORMATION

STATION MODEL


Amount of cloud cover
(approximately ¾ covered)
Temperature (°F)
28
Present weather
*
Barometric Pressure
196
(1019.6 mb)
Visibility (mi)
1/2
+19/
Barometer Trend
(a steady 1.9mb rise the past 3hours)
Dewpoint (°F)
27
.25 Precipitation
(inches past 6 hours)
Wind speed
whole feather = 10 knots
half feather = 5knots
total = 15knots
Wind direction
(from the southwest)
(1 knot = 1.85 km/hr)


Present Weather
SYMBOLS
Rain
Fog
Snow
Hail
Showers
Thunder-storms
Drizzle
Sleet

LESSON 4

TOPIC: High-pressure areas

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E4, E5, E6

PROCESS SKILLS: 13, 14, 17

AIM: What are the characteristics of high-pressure areas?

MATERIALS:

- Reference Sheets 1, 2, and 3 (duplicate and/or use overhead transparencies)
- air pump (hand)

PERFORMANCE OBJECTIVES: Students will be able to:

- define isobar.
- describe the characteristics of a high-pressure system.
- describe the movement of wind around a high.
- interpret information on a weather map.
- summarize the type of weather associated with high pressure.

MOTIVATION:

- Display or distribute copies of Reference Sheet 1. Discuss the information this weather map provides. Ask students how they can locate the areas of high pressure.

PROBLEM: What type of weather is associated with high pressure?

AIM: What are the characteristics of high-pressure areas?

DEVELOPMENTAL STRATEGIES:

- If the class does not remember how to use isobar to determine areas of high pressure, review this with them. (Isobars are lines connecting points of equal air pressure.) Label the high-pressure areas on the transparency with an H.

- Discuss the type of weather associated with high pressure. Distribute copies of (or display) Reference Sheet 3. Include temperature, sky condition, and precipitation in the discussion.

- Ask the class to describe the movement of wind around the H (see Reference Sheet 2). The station models, shown on Reference Sheet 1, indicate that the winds blow clockwise and out from the center of the high. This is known as anticyclonic circulation.

- Ask the class to summarize the information obtained from weather maps. Record the summary on the chalkboard. It should include the following statements:

  - High pressure is designated with an H on a weather map.
  - Highest air pressure, shown by isobars, is in the center of the high.
  - Fair and clear weather is usually associated with the high.
  - Winds blow out from the center of the high in a clockwise (anticyclonic) direction.

- As air descends in high-pressure areas, it is compressed by the continually increasing weight of the air above it, and this compression causes the air to become warmer. (Use an air pump and feel the needle after pumping--compressing--the air.) This warming of air results in generally fair and clear weather. Warm air has a greater capacity to hold water vapor, and the air will have lower relative humidity and be clear.

SUMMARY:

- High-pressure areas (highs) are regions of relatively high atmospheric pressure, represented on a surface weather map by closed isobars.

- Winds blow clockwise (anticyclonic circulation) within a high and spiral outward from the center.

- The air in highs tends to descend and is warmed by compression, resulting in generally fair and clear weather.

HOMEWORK:

- What weather is associated with high-pressure areas?

- What causes an air mass to have high pressure?

- In which direction does air move inside a high-pressure area?

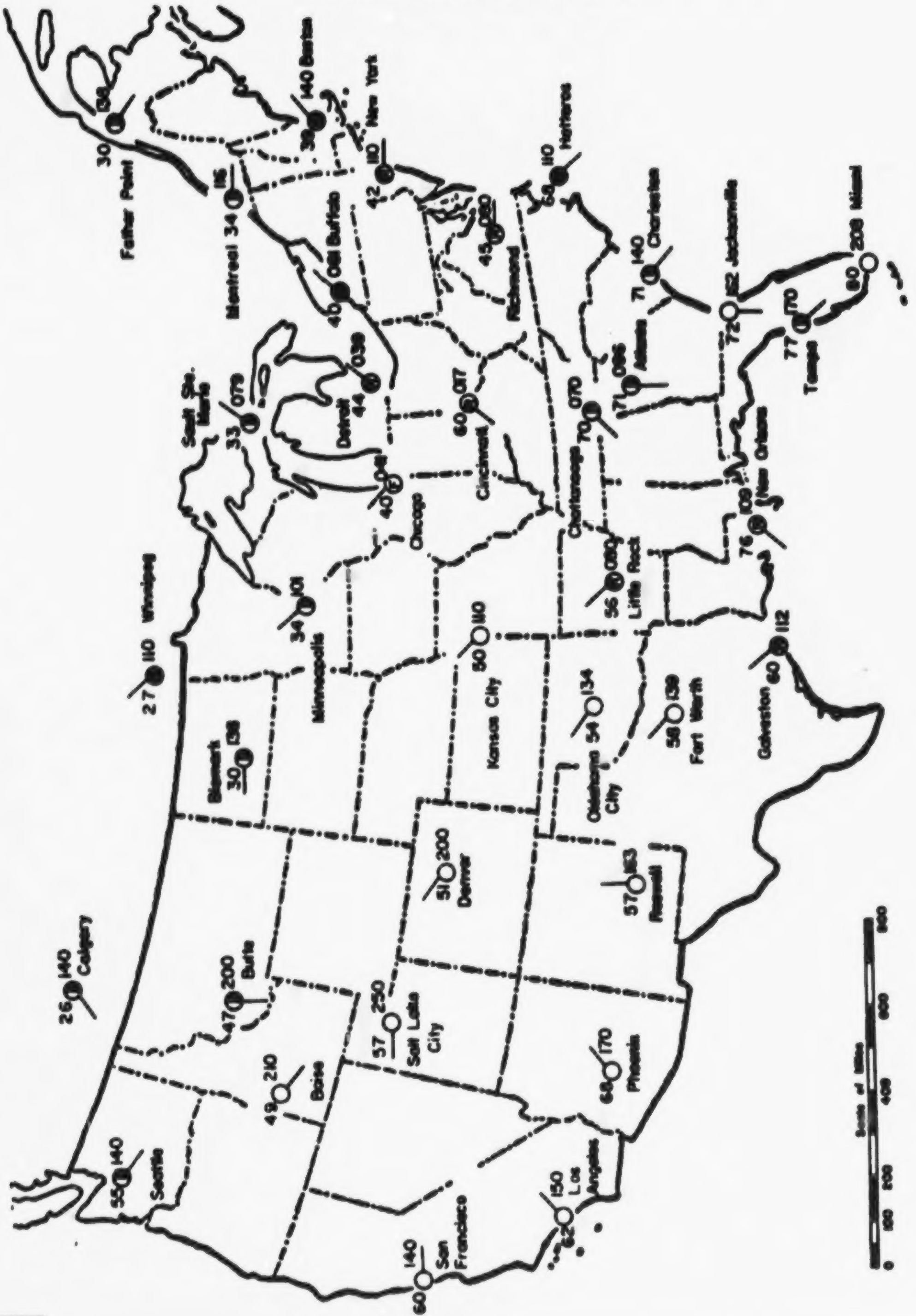
ENRICHMENT:

- Record air pressure, precipitation, air temperature, and wind direction for a period of a month. Graph the results and determine any relationships between the observed factors.

- Write a report on the history of the United States Weather Service. (See National Oceanic and Atmospheric Administration for information.)

- Construct a barometer and calibrate it in millibars or millimeters of mercury. Use your homemade barometer to record air pressure and compare your results with the U.S. Weather Bureau (212-315-2705 or 212-976-1212).

WEATHER DATA MAP OF THE U. S.


30 136 Father Point
Montreal 34 116
140 Boston 38
110 New York 42
40 018 Buffalo
110 Hatteras 64
45 080 Richmond
71 140 Charleston
72 112 Jacksonville
208 Miami 80
77 170 Tampa
71 086 Atlanta
70 070 Chattanooga
60 077 Cincinnati
44 038 Detroit
33 079 Sault Ste. Marie
40 048 Chicago
76 100 New Orleans
56 080 Little Rock
34 101 Minneapolis
27 110 Winnipeg
50 110 Kansas City
60 112 Galveston
34 134 Oklahoma City
58 138 Fort Worth
30 138 Bismarck
51 200 Denver
57 183 Roswell
26 140 Calgary
47 200 Butte
57 250 Salt Lake City
49 210 Boise
68 170 Phoenix
55 140 Seattle
62 150 Los Angeles
60 140 San Francisco
Scale of Miles
0 100 200 400 600 800

MAP KEY

Temperature Reading → 51

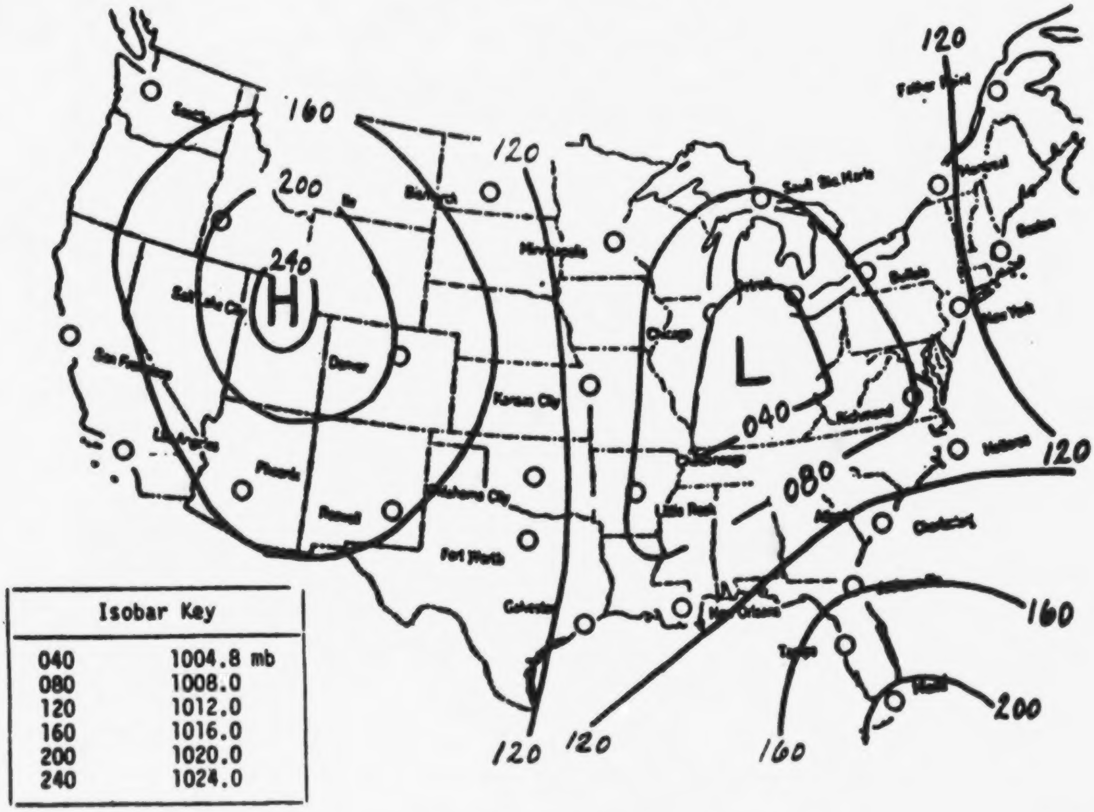
250 ← Barometric Pressure (250=1025.0 mb.)

Wind direction, circle is head of arrow → Ⓡ ← Circle Indicates: cloud cover

◐ = ½ Overcast; ● = Complete overcast;

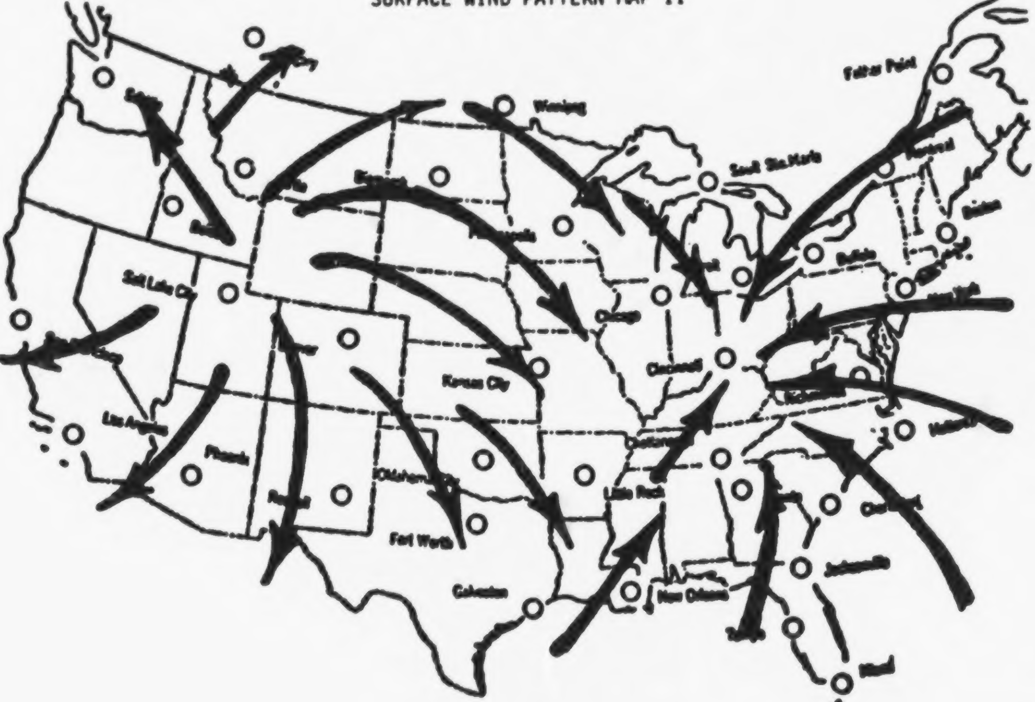
○ = Clear skies; Ⓡ = Rain; Ⓕ = Fog

ATMOSPHERIC PRESSURE MAP I

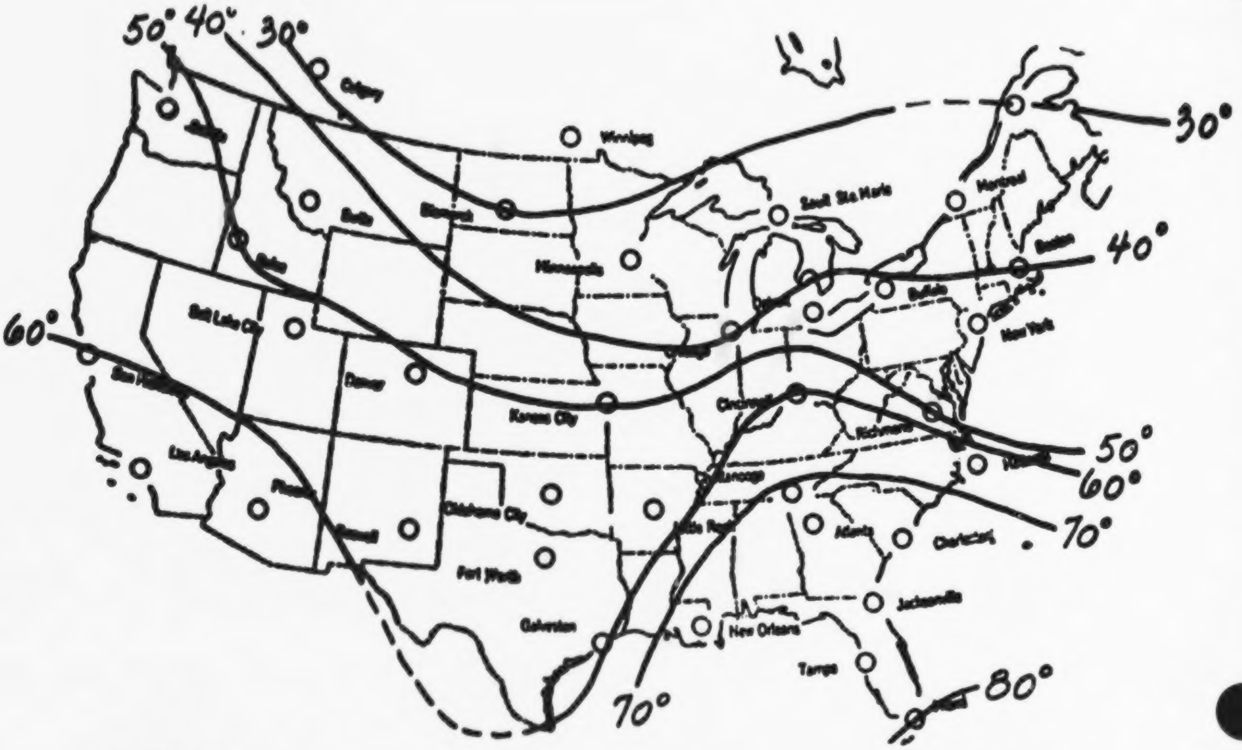

120
160
120
200
240
H
L
040
080
120
120
160
200
120
120
160
Seattle
Bismarck
Minneapolis
Salt Lake City
San Francisco
Denver
Kansas City
Los Angeles
Phoenix
Roswell
Oklahoma City
Fort Worth
Galveston
Chicago
Little Rock
New Orleans
Sault Ste Marie
Buffalo
New York
Boston
Father Point
Richmond
Hatteras
Charleston
Tampa
Miami

Isobar Key	
040	1004.8 mb
080	1008.0
120	1012.0
160	1016.0
200	1020.0
240	1024.0

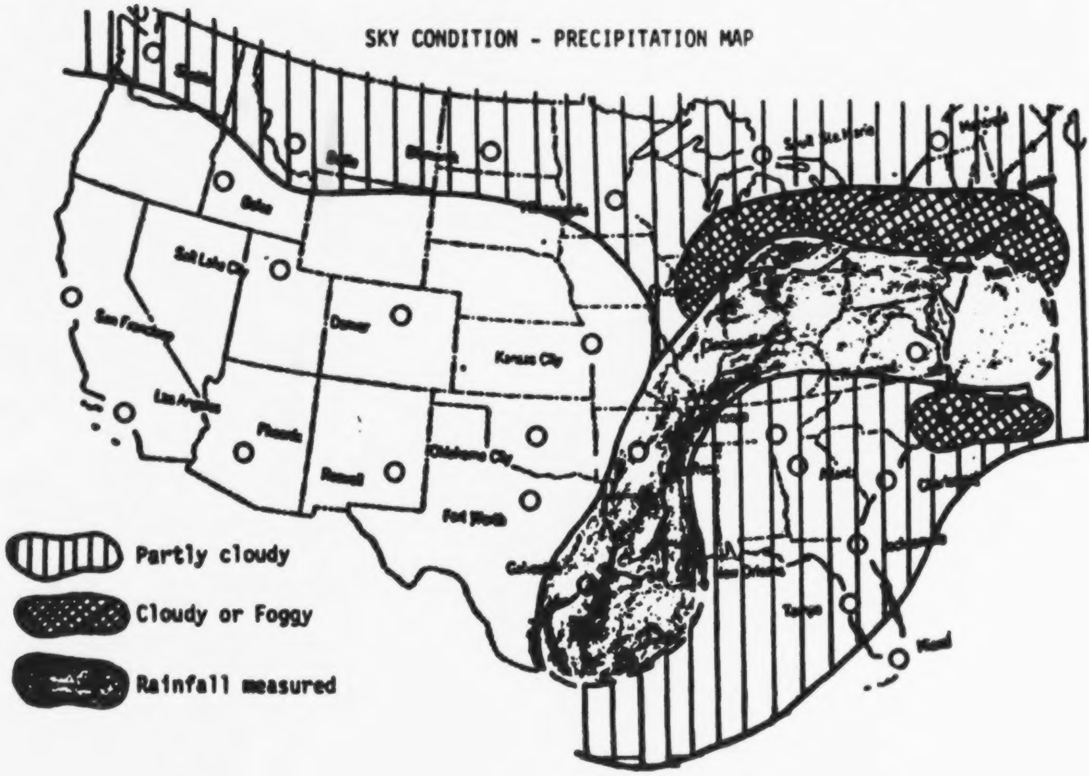
SURFACE WIND PATTERN MAP II


Father Point
Winnipeg
Sault Ste Marie
Boston
Buffalo
New York
Salt Lake City
Chicago
Kansas City
Los Angeles
Phoenix
Roswell
Oklahoma City
Fort Worth
Galveston
Little Rock
New Orleans
Richmond
Hatteras
Charleston
Jacksonville
Tampa
Miami

SURFACE TEMPERATURE MAP


50°
40°
30°
Calgary
Seattle
Winnipeg
30°
Sault Ste Marie
Montreal
Butte
Bismarck
Boston
40°
Minneapolis
Boise
Buffalo
New York
Salt Lake City
60°
San Francisco
Denver
Chicago
Kansas City
Cincinnati
Richmond
50°
Norfolk
60°
Los Angeles
Memphis
Phoenix
Oklahoma City
Roswell
Little Rock
Atlanta
Charleston
70°
Fort Worth
Jacksonville
Galveston
New Orleans
Tampa
80°
70°
Miami

SKY CONDITION - PRECIPITATION MAP


Seattle
Sault Ste Marie
Montreal
Butte
Bismarck
Boise
Minneapolis
Salt Lake City
San Francisco
Denver
Kansas City
Chicago
Los Angeles
Phoenix
Oklahoma City
Roswell
Atlanta
Charleston
Fort Worth
Galveston
New Orleans
Jacksonville
Tampa
Miami
Partly cloudy
Cloudy or Foggy
Rainfall measured

LESSON 5

TOPIC: Low-pressure areas

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E4, E5, E7

PROCESS SKILLS: 13, 14, 17

AIM: What are the characteristics of low-pressure areas?

MATERIALS:

- Reference Sheets 1, 2, and 3 from Lesson 4 (duplicate and/or use as overhead transparencies)

PERFORMANCE OBJECTIVES: Students will be able to:

- describe the characteristics of a low-pressure system.
- describe the movement of wind around a low.
- interpret information on a weather map.
- summarize the type of weather associated with low pressure.

MOTIVATION:

- Display or distribute copies of Reference Sheet 1. Discuss the information this weather map provides. Ask students how they could locate the areas of low pressure.

PROBLEM: What type of weather is associated with low pressure?

AIM: What are the characteristics of low-pressure areas?

DEVELOPMENTAL STRATEGIES:

- The class should be able to use the isobars to determine areas of low pressure. Label these areas on the transparency with an L.

- Describe the type of weather associated with low pressure. Distribute copies of (or display) Reference Sheet 3. Include temperature, sky condition, and precipitation in the discussion.

- Ask the class to describe the movement of wind around the L (see Reference Sheet 2). The station models, shown on Reference Sheet 1, indicate that the winds blow counter-clockwise and in toward the center of the low. This is known as cyclonic circulation.

- Ask the class to summarize the information obtained from the weather maps. Record the summary on the chalkboatd. It should include the following statements:

- Low pressure is designated with an L on a weather map.
- Lowest air pressure, shown by isobars, is in the center of the low.
- Cloudy and sometimes stormy weather is usually associated with the low.
- Winds blow toward the center of the low in a counter-clockwise (cyclonic) direction.

. As air rises in low-pressure areas, it expands because the weight of the air above it continually decreases. This expansion causes the air to become cooler (as, for example, air escaping from a tire expands and cools). This cooling of air results in generally cloudy or stormy weather. Cool air has a lower capacity to hold water vapor, and the air will have higher relative humidity and be cloudy or produce precipitation.

SUMMARY:

. Low-pressure areas (lows) are regions of relatively low atmospheric pressure, represented on a surface weather map by closed isobars.

. Winds blow counter-clockwise (cyclonic circulation) within a low, and spiral toward the center.

. The air in lows tends to rise and cool by expansion, resulting in generally cloudy or stormy weather.

HOMEWORK:

- What weather is associated with low-pressure areas?

- What causes an air mass to have low pressure?

- In what direction does air move inside a low-pressure area?

ENRICHMENT:

- Write a report on adiabatic temperature changes.

- Write a report on one of the major types of storms associated with low air pressure (hurricanes, tornadoes, etc.).

- Draw and label a diagram illustrating the movement of air from high pressure (H) to low pressure (L).

UNIT IV

LESSON 6

TOPIC: Fronts

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E8, E9, E10

PROCESS SKILLS: 1, 2, 9, 14, 15

AIM: How do fronts affect our weather?

MATERIALS:

- Reference Sheet 1 from Lesson 4
- transparencies or other visual aids of a cold front, a warm front, a stationary front, and an occluded front
- large corked (stoppered) bottle
- water
- motor oil
- weather maps showing the various fronts (including symbols of fronts)

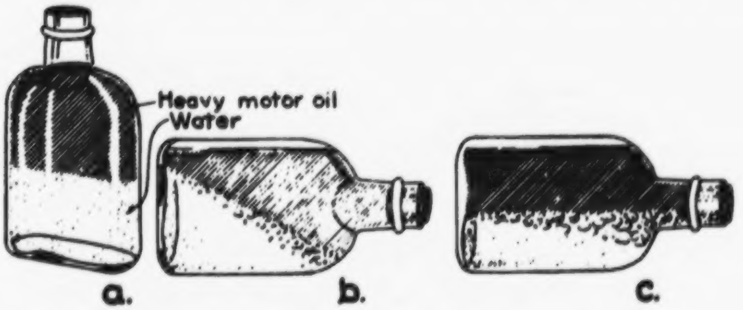
PERFORMANCE OBJECTIVES: Students will be able to:

- define front.
- explain why the air between two air masses generally does not mix.
- explain the weather characteristics associated with cold, warm, stationary, and occluded fronts.
- identify the various symbols of fronts on a weather map.

NOTE: At this point begin saving daily weather maps from a local newspaper. You will need a series of consecutive weather maps for Lesson 11.

MOTIVATION:

- A rather crude analogy may be helpful in clarifying the meaning of the terms cold front and warm front. Fill a flat bottle halfway with water and fill the remainder with heavy motor oil. Cork the bottle and tip it to one side as shown in figure below. The boundary between the two liquids is the front.



- The water represents a cold air mass and the less dense oil represents a warm air mass. Show how the water moves under the oil and how the oil slides over the water. Note the turbulence that occurs along the front in (b) and (c) where the two different fluids are in contact. Discuss the limitations of this simple model.

PROBLEM: What type of weather is associated with fronts?

AIM: How do fronts affect our weather?

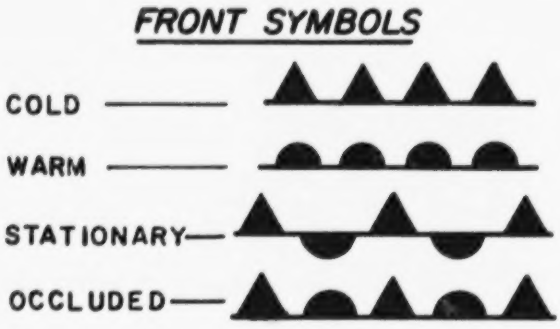
DEVELOPMENTAL STRATEGIES:

- Examine the regions between air masses on transparency Reference Sheet 1 from Lesson 4.

- Ask the students where they believe fronts are located. Draw in the cold front and the warm front, using the correct symbols.

- Using prepared visual material, show examples of all types of fronts and the weather associated with each one. Ask the students to prepare a chart similar to the one below, listing the front and the type of weather associated with it. Ask the class: "If a front is the boundary between two air masses, how do you know whether to designate it cold or warm?" After looking at Reference Sheet 1 and/or other visual material, elicit that the front is named after the approaching air mass. Thus, a cold front is the leading edge of a mass of cold air that meets and replaces warm air.

FRONT	AIR MOVEMENT	TYPE OF WEATHER
Cold	cold air forces its way under warm air and pushes it upward	temperature drop, violent storms of short duration, cumulo-nimbus clouds
Warm	warmer air overtakes and rises over cooler air	temperature rises, long period of steady rain, clouds in advance of front
Occluded	cold front overtakes a warm front	steady rain or showers
Stationary	two air masses separated by a front that is not moving	long period of steady rain



SUMMARY:

- Air masses come into direct contact with one another, but the air in them does not readily mix because of density differences.

- The boundaries separating air masses tend to remain distinct. These are called fronts.

- Abrupt changes in weather elements can occur across fronts.

- The kind of front depends upon motion of the boundary or boundaries between different air masses.

- Types of fronts include cold, warm, stationary, and occluded.

- In general, particular weather is characteristic of each kind of front.

HOMEWORK:

- Explain how weather is affected by fronts.

- Explain why warm fronts are associated with a long, lingering rain.

- Discuss why thunderstorms may occur with the arrival of a cold front.

- Describe the weather in an area after the following fronts pass: a cold front, warm front, and occluded front. Discuss what happens to the temperature, air pressure, and sky condition.

ENRICHMENT:

- Draw and label diagrams representing the various types of fronts.

- Write a report on the thunderstorm.

- Follow the movement of fronts on a weather map for one week. Report on the speed with which the fronts move and the weather associated with them. (Discuss the weather in an area as it existed before the front arrived, when the front was there, and after the front passed through.)

LESSON 7

TOPIC: Wave cyclones

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E

PROCESS SKILLS: 1, 2, 9, 17

AIM: What type of weather is associated with a wave cyclone?

MATERIALS:

- a transparency of the Reference Sheet
- weather maps showing wave cyclone formation (if available)
- convection box
- candle

PERFORMANCE OBJECTIVES: Students will be able to:

- define wave cyclone.
- identify the features associated with a wave cyclone.
- explain the formation and history of a wave cyclone.
- describe the weather associated with a wave cyclone.

MOTIVATION:

- Demonstrate the convection box, and elicit that hot air rises and cold air sinks.

- Display transparency of the wave cyclone model. Ask students to describe any similarities between it and the convection box demonstration.

PROBLEM: Describe the formation and history of a wave cyclone.

AIM: What type of weather is associated with a wave cyclone?

DEVELOPMENTAL STRATEGIES:

- Using the box, be sure the students observe that differences in temperature cause differences in air pressure, which result in air rising over the hot candle and sinking into the cooler opening of the convection box.

- Different temperature air masses, which form in high and middle latitudes, often duplicate the air flow illustrated by the convection box. The temperature and pressure differences of air masses can form a wavelike movement of air from high pressure to low pressure.

- Elicit that the wave cyclone model has the following properties:

  - center of low air pressure
  - warm and cold air sectors
  - fronts
  - cloud and precipitation areas
  - cyclonic circulation

- Challenge the class to create a model of a typical wave cyclone, i.e., cold front and warm front weather occurs, an occluded front forms, low pressure dissipates and clear weather dominates until the next system arrives.

SUMMARY:

- A wave cyclone or low occurs at boundaries of relatively warm and cold air.

- A wave cyclone is a counter-clockwise movement of air (cyclonic circulation) toward a low.

- Wave cyclones frequently form in the middle and high latitudes.

- Wave cyclones typically exhibit the following characteristics:

  - a center of low air pressure
  - warm and cold air sectors
  - fronts
  - cloud and precipitation areas
  - cyclonic circulation

- Wave cyclones may be viewed as having a life history in which the system forms, intensifies, and eventually dissipates.

- Wave cyclones may or may not change latitude as they move in a generally easterly direction over the contiguous United States.

HOMEWORK:

- Explain the cause of a typical wave cyclone.

- Describe the weather associated with each phase of the wave cyclone.

- Describe the movements of fronts associated with the wave cyclone model.

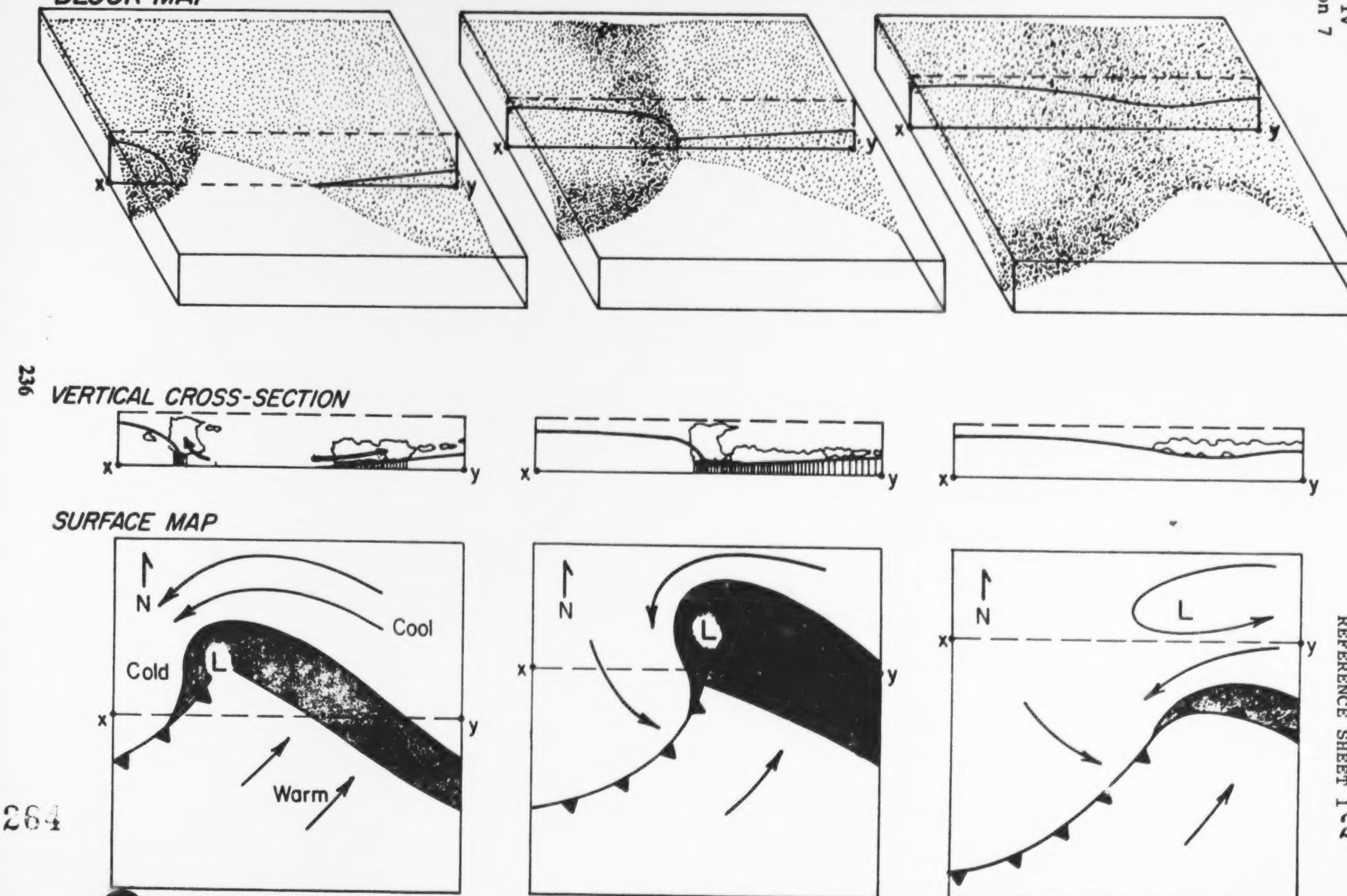
ENRICHMENT:

- Write a report on tornadoes or hurricanes, and relate these storms to the wave cyclone model.

- Create a computer-generated model that would demonstrate the cyclonic flow of air around a low-pressure area, and illustrate the history of the wave cyclone model.

- Collect weather maps that show the formation of a typical wave cyclone. Report on the changes in air temperature, air pressure, sky conditions, and precipitation as the wave cyclone forms, intensifies, and then dissipates.

WAVE CYCLONE MODEL


BLOCK MAP
x
y
x
y
x
y
VERTICAL CROSS-SECTION
x
y
x
y
x
y
SURFACE MAP
N
Cool
Cold
L
x
y
Warm
N
L
x
y
N
L
x
y

REFERENCE SHEET 1

UNIT IV

LESSON 8

TOPIC: Weather elements

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E8

PROCESS SKILLS: 1, 2, 3, 4, 5, 6, 7, 9, 12, 13, 14, 16, 19, 20

AIM: What are the elements of weather?

MATERIALS:

- thermometer
- barometer
- anemometer
- rain gauge
- wind vane
- copies of weather maps
- Student Worksheet

PERFORMANCE OBJECTIVES: Students will be able to:

- list the elements of weather.
- identify the instruments used to record these elements.
- design a method for collection of weather data.

MOTIVATION:

- If you were a meteorologist, what facts would you need to know in order to accurately forecast the weather?

PROBLEM: Recall the last weather forecast you saw. What elements of weather did the forecaster discuss?

AIM: What are the elements of weather?

DEVELOPMENTAL STRATEGIES:

- Ask, "What are the elements of weather?" Responses should include: temperature, air pressure, humidity, wind direction, wind speed, and sky conditions. Students may include the wind-chill factor or the temperature-humidity index. It is not necessary to go into the latter two at this time: just tell the class that these are not direct measurements of conditions that are occuring in the atmosphere.

- Tell students that they are going to become weather forecasters, and ask them what information they think they will need. Let them discuss which data they will need to gather, being sure they understand that they will need to have this data over a long period of time. Introduce the concept of a weather watch, a long-term project.

- Assign students to collect weather data over a two-week period of time. It would be highly desirable for the school to have a weather station so that the students can measure temperature, air pressure, humidity, precipitation, and wind at approximately the same time each day. If this is not possible, a weather watch can still be done using information from the radio. You can assign students to bring in information in the morning, and plot it on a class chart, or each student can be responsible for his/her own information. By actually seeing the day-to-day relationships among the various weather factors, the students will better understand them.

- Distribute enough copies of the handout "Weatherwatch" for each student to record data over a two-week period.

- Ask students what instruments are used to measure the various elements of weather. The basic principle of each of the weather instruments should be stressed.

  - The thermometer measures air temperature because of the even expansion and contraction in proportion to the temperature changes of the substance used as the indicator.

  - The barometer measures air pressure by using a column of mercury which rises or falls depending upon the air pressure at the moment.

  - The wind vane measures wind direction because it has a smaller vane at one end and a larger vane at the other end. Since the wind exerts a greater total force on the large vane, it swings away from the wind, pointing the small vane into the wind.

  - The anemometer measures wind speed because it catches the wind in its cups, and is caused to rotate. The rate of rotation is proportional to wind speed.

  - Precipitation is measured by a rain gauge, which is a funnel placed in a graduated collecting can. The water level is then read.

- Make sure that the students understand the broad picture of what happens to weather data after they are collected. The weather maps that they see on TV and in the newspaper are the outgrowth of data collection from many cities. (These, too, will be dealt with in detail in a future lesson. At this time it is the overview that is important.)

SUMMARY:

- Weather elements include temperature, air pressure, humidity, wind direction, wind speed, cloudiness, and precipitation.

- The study of weather requires the collection of data for selected weather elements.

- Instruments are used to collect weather data.

- Weather maps evolve from observations taken simultaneously at many locations.

HOMEWORK:

- Watch or listen to at least two different weather reports on different stations or channels. Answer these questions about the reports:
    - Which factors were mentioned in both forecasts?
    - Were there any factors mentioned in one that were not in the other? If so, which one(s)?
    - How far in advance were the forecasts for?
    - What other terms were mentioned that were not gone over in class?

ENRICHMENT:

- Visit a U.S. weather station. There are several in the New York City area. You might visit the weather station at the Hall of Science in Flushing Meadow Park. Find out how weather data are collected at these stations.

- If you have a flagpole, you can record simple wind information over a period of time. Figure out how you can use a flag to discover wind speed and direction, and then keep hourly records for a day.

- Find out which types of companies employ meteorologists. What do the forecasters do for these companies?

- Find out how collection of weather data is different today from the way it was fifty years ago.

- Are weather forecasters always wrong? Start keeping a track record of forecasts and actual weather. Remember: be fair to the forecaster (if he/she said it was going to be 55° F and it only got to 53° F, is he/she wrong?) and record relative accuracy over the next few weeks.

- Look up the forecast in the Almanac. How accurate was that? How far in advance do you think you can forecast the weather?

WEATHER WATCH

	Date														
Air Temperature in °F	80														
	70														
	60														
	50														
	40														
	30														
	20														
	10														
Atmospheric Pressure in mb.	1040														
	1030														
	1020														
	1010														
	1000														
	900														
	Wind direction, speed, and sky cond. Cloud type Weather														
Precip. in inches	0.5														
	0.3														
	0.1														

LESSON 9

TOPIC: Atmospheric pressure and temperature

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E/II A1

PROCESS SKILLS: 1, 2, 8, 9, 10, 14, 20

AIM: How are air temperature and air pressure related?

MATERIALS:

- Celsius thermometer
- other types of thermometers, such as maximum-minimum, recording, etc.
- barometer
- narrow-necked jar
- hard-boiled egg (peeled)
- match
- drinking glass
- card large enough to cover mouth of glass
- small aluminum can
- nail
- hammer

PERFORMANCE OBJECTIVES: Students will be able to:

- design a demonstration of air pressure.
- show how changes in air pressure can have an effect on their lives.
- explain the relationship between air temperature and air pressure.

MOTIVATION:

- Display a hard-boiled egg and a jar. The jar neck should be just small enough so that the egg will not fall through. (A small egg works well with an old-fashioned milk bottle.) Show students that the egg will not fit through the mouth of the jar. Ask them how they think the egg could be made to slip through the neck of the jar.

NOTE: Motivation demonstration should be attempted in advance.

PROBLEM: What factors influence the pressure on the egg?

AIM: How are air temperature and air pressure related?

DEVELOPMENTAL STRATEGIES:

- Ask students for suggestions that do not involve directly heating the milk bottle (remember what you're after is the relationship between the jar temperature and the air pressure).

- If no one comes up with a workable idea, remind the students that they have previously studied temperature and pressure. Review these concepts.

- Elicit a definition of temperature. (Temperature is a measurement of the kinetic energy, i.e., energy of motion of particles. It also indicates the direction of heat flow. Heat flows from a warmer to a cooler object until both are at the same temperature.) Again, explain how temperature is measured. This time you might have a variety of thermometers for students to see. A maximum-minimum thermometer is a good one to show them as all the weather reports include the high and low temperatures for the day.

- Discuss air pressure. Ask the students how they can demonstrate that air exerts pressure. Show the equipment on the desk and ask them to design a demonstration to show air pressure. Some very simple ideas are as follows: Fill the glass with water, put the card over the mouth of the glass and invert the glass. The air pressure will hold the card in place, and contain the water. More spectacularly, make a small nail hole near the bottom of the aluminum can. Fill the can with water while holding a finger on the nail hole. Now place your other hand on top of the can and release the finger from the hole. No water flows through the hole. Lift the top hand and water will flow from through the hole.

- Draw on the board two equal-sized squares. Label one "hot" and the other "cold." Ask the students how they think the air pressure would compare for two equal volumes of air heated to different temperatures. Using the "cold" square, draw numerous circles representing air molecules. Elicit that the distance between the molecules increases as the air is heated. Now draw molecules further apart in the "hot" square, and have the students observe that there would be considerably fewer molecules in hot air, therefore less air pressure.

- Return to the motivation. Now the students should be able to tell you that by using up the oxygen (combustion) in the bottle you decrease the pressure and the egg will be pushed in by the greater outside air pressure. Try it. Be sure the bottle is dry. Throw in a burning match. Immediately set the peeled hard-boiled egg in the mouth of the jar. As the match is extinguished, the egg will be pushed into the jar.

- To summarize, ask students to think of the beach or a large lake. During a summer afternoon, the land is warmer than the water. This causes the air over the land to be warmer than the air over the water. Therefore, the air over the land had lower pressure and is pushed upward by cooler, denser air that flows in from over the water. Students will recall that at the beach on a summer afternoon, the breezes come off the water.

- Stress the importance of temperature and air pressure to an understanding of weather patterns.

SUMMARY:

- Air pressure is the force exerted by the molecules in the atmosphere.

- Air pressure and temperature are important factors in weather prediction.

- Heating of air results in a decrease of pressure.

HOMEWORK:

- List two types of thermometers. Explain how each of them works.
- Other than the demonstrations done in class, describe another way to prove that air exerts pressure.
- What do you think would happen to the reading on a barometer if you took it up the side of a mountain? Why?
- What would happen to the air pressure if you cooled a mass of air? Why?

ENRICHMENT:

- Design an experiment to get the hard-boiled egg from today's lesson out of the bottle (in one piece). Try it in the classroom.
- Watch or listen to a weather report. How does the weather reporter talk about air pressure? What do you notice that seems to go along with changes in air pressure?
- Prepare a report on the relationship between sinus trouble and air pressure changes.
- Read a cake mix box and notice the high-altitude directions. Explain why these directions are included.

UNIT IV

LESSON 10

TOPIC: Moisture in the atmosphere

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E/II A1, A2; E/IV A, B

PROCESS SKILLS: 1, 2, 3, 4, 5, 6, 13, 14, 17

AIM: How does water get into the atmosphere?

MATERIALS:

For each student:
- a copy of the Reference Sheet

Per lab group:
- shiny metal can
- thermometer
- crushed ice

PERFORMANCE OBJECTIVES: Students will be able to:

- define the terms dew point and relative humidity.
- explain that moisture is held in the air.
- design an experiment to find the dew point of the air.
- demonstrate the use of the relative humidity chart.
- compare relative humidity on two different days, given air temperature and dew point.

MOTIVATION:

- Wash a small section of the chalkboard with a sponge. As the water evaporates, ask the students what is happening to the water vapor.

PROBLEM: How can we show that there is water vapor in the air?

AIM: How does water get into the atmosphere?

DEVELOPMENTAL STRATEGIES:

- Elicit that the water from the chalkboard evaporates into the air, and that in order to prove that it is there, it must condense again.

- Students should understand that condensation requires cooling. Ask them how they could cool the air in order to see the moisture in it. If they are having trouble, ask them to describe the outside of a soda glass just after it has been filled with cold liquid. Ask students what the droplets on the side of the glass are (water). Elicit the origin of these droplets (the air in the room contains water vapor molecules). Ask why the molecules condense (the water molecules lost energy).

- Show students the materials available. Ask them to design an experiment to find the temperature at which droplets will condense out of the air.

- Instruct students to place room-temperature water into their shiny metal cans, along with a thermometer. Add very small pieces of ice, bit by bit, stirring after each addition. Measure and record the temperature of the water the moment droplets of water begin to form outside of the cans. The temperature they have just found is defined as the dew point.

NOTE: This test can be done with beakers or any other glassware if cans are not available, but the results will not be as easy for the students to see.

- Discuss class results. Ask students what they think would happen to the dew point if there were four times as much moisture in the room. Remind them of their bathroom when they take a bath or shower. Moisture droplets are deposited on windows and glass surfaces even though they are not nearly as cold as the metal can. Students should understand that the more humid the air, the closer the dew point is to the air temperature.

- Explain that the amount of water held in the air can change from one day to the next.

- Explain that the moisture reported in the weather reports is called relative humidity. This is the amount of moisture held in the air compared to what the air is capable of holding at that temperature and pressure. It is necessary to know the dew point to find the relative humitity. Give the class the example of two different days when the air temperature is exactly the same. For example:

Day 1	Day 2
Air temperature = 20° C	Air temperature = 20° C
Dew point = 10° C	Dew point = 12° C

  The students should understand that Day 1 must be a drier day than Day 2 since the temperature has to drop more on Day 1 before moisture will condense from the air.

- Distribute copies of the Reference Sheet. Have students practice finding the relative humidity from the chart when they are given the dew point and the air temperature. They should understand that the closer together the dew point and the air temperature are, the more likely water is to condense, and therefore the more likely it is to rain.

SUMMARY:

- Moisture is held in the air.

- Variations in water vapor content of the air are basic to many atmospheric processes.

- Both absolute and relative water vapor measurements are important in the study of weather.

- The dew point is the temperature at which moisture condenses from the air.

- The dew point varies from day to day.

- The relative humidity of the air can be calculated from the dew point.

- The higher the dew point, and thus the relative humidity, the more likely it is to rain.

HOMEWORK:

- You drink a glass of cold soda and notice a "ring" left on the table. What caused that ring to form?

- Explain why dew forms on the grass overnight.

- Using the relative humidity chart, find the following relative humidities:

  . air temperature = 20°C; dew point = 12°C
  . air temperature = 20°C; dew point = 18°C

- In the above question, on which day would it be more likely to rain?

ENRICHMENT:

- Humdidity can be measured by a device called a hygrometer. Find directions on how to make one, construct it, and bring it to class.

- In mail-order catalogs and gift shops they sell devices that turn colors depending on the amount of moisture in the air. Find out how these objects work.

- Why are there little inedible packages inside bottles of vitamins, as well as in packages that cameras come in? What do they do?

- What is frost? Under what conditions does it form?

RELATIVE HUMIDITY (%)

Dew Point Temperature °C

Air Temperature °C	0	2	4	6	8	9	12	14	16	18	20	22	24	26	28	30
0	100															
2	87	100														
4	75	87	100													
6	66	75	87	100												
8	57	65	76	87	100											
10	50	57	66	76	88	100										
12	44	50	58	67	77	88	100									
14	39	44	51	59	68	77	88	100								
16	34	39	45	52	59	68	77	88	100							
18	30	34	40	45	52	60	68	77	88	100						
20	26	30	35	40	46	53	60	68	77	88	100					
22	23	27	31	36	41	47	53	61	69	79	89	100				
24	21	24	27	31	36	41	47	53	61	69	78	88	100			
26	18	21	24	28	32	37	42	47	54	61	69	78	89	100		
28	16	19	22	25	28	32	37	42	48	55	62	69	79	89	100	
30	15	17	19	22	26	29	33	38	43	49	55	62	71	80	90	100

UNIT IV

LESSON 11

TOPIC: Weather forecasting

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E9, E10

PROCESS SKILLS: 2, 14, 15

AIM: How can we forecast the weather?

MATERIALS:

- copies of the student weather maps you have been collecting since Lesson #6 (one set of maps for each student). (They should have the dates removed, and be in order. The last map in the series should be from the day before this lesson.)

PERFORMANCE OBJECTIVES: Students will be able to:

- explain what information is needed to forecast the weather.
- demonstrate the ability to read a weather map.
- explain the role of the National Weather Service in gathering and disseminating weather information.
- apply their knowledge to predict the weather for the current day.

MOTIVATION:

- Inform students that they are going to write a weather forecast. Ask students what information they will need to know.

PROBLEM: How is it possible to predict the weather?

AIM: How can we forecast the weather?

DEVELOPMENTAL STRATEGIES:

- Ask the class what they think they would need to know to predict the weather for a given location. They should answer with all of the weather factors that have been discussed previously, including high- and low-pressure air masses.

- Elicit why people need to know what the weather will be. Make sure students realize that it is more important than just being able to pick out suitable clothing. Have them make a list of some occupations which depend on knowledge of the weather.

- Inform the students that the National Weather Service is the government agency that has the responsibility for making weather forecasts. The NWS also puts out a crop bulletin, a bulletin covering flooding of the Mississippi River, and various harbor bulletins. The National Severe Storms forecast center in Kansas City, MO forecasts thunderstorms and tornadoes, while the National Hurricane Center in Miami, FL is responsible for hurricane forecasts, warnings, and watches. Forecasts are also made for Fire-Alert Weather, Fruit-Forest Service, and Aviation. The NWS uses the same information that is available to the students with certain extras, such as satellite photographs and upper-atmosphere observations.

- Help the class realize that short-term forecasts are much more accurate than long-range forecasts. Long-range forecasts are possible, however, since there is a tendency for weather systems to remain the same from one day to the next.

- Have the students attempt to predict the weather. Give them the handout sheet that you have prepared. It should have copies of three or four consecutive weather maps with the days and dates omitted. (You don't want the students to realize the weather under investigation is for today, and just look out the window!) Number the maps in order, and tell the students that their job will be to determine the map for the next day. You may wish to have the students work in groups of two for this; it may help them to discuss the problem with another student. Eventually, they should understand that it is the pattern of the high- and low-pressure systems that is important, and that these systems move from west to east across the United States.

- After the students have discussed the predicted weather for the next day in the series, tell them they have been forecasting the weather for today, and have them verify their predictions.

SUMMARY:

- Weather forecasts make use of all weather factors.

- Forecasters make use of satellite photographs and upper-atmosphere readings as well as information taken near ground level.

- The National Weather Service is responsible for forecasting weather for many different purposes.

- There is a tendency for weather systems to remain the same from one day to the next.

- The goal of weather forecasting is to make an accurate prediction of future weather. Radar, computers, and weather satellites have helped to improve weather forecasting.

HOMEWORK:

- Explain how a knowledge of weather forecasting is useful to farmers.

- Explain how NASA uses weather forecasts.

- Listen to a weather forecast tonight. How did it compare to the one you did in class?

- Use the class weather watch information to predict the weather. Analyze the the information on the data table, find the relationships, and predict the actual numbers for tomorrow. Check your accuracy.

ENRICHMENT:

- Find a copy of an old Farmer's Almanac. Report on what weather factors are discussed, and any other interesting bits of weather lore you find.

UNIT IV

LESSON 12

TOPIC: Composition of the atmosphere

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E11

PROCESS SKILLS: 1, 2, 7

AIM: What is the composition of the atmosphere?

MATERIALS:

- piece of steel wool
- vinegar
- beaker
- test tube

PERFORMANCE OBJECTIVES: Students will be able to:

- list the substances present in the atmosphere.
- explain the possible effects of an increase in carbon dioxide in the atmosphere.
- give examples of the ways in which both human-caused and natural pollutants may enter the atmosphere.

MOTIVATION:

- Why haven't life forms as we know them been identified on any of the planets or satellites in our solar system?

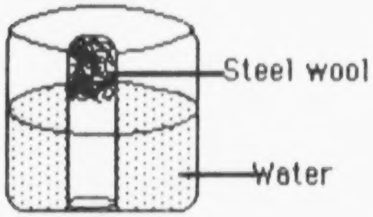
PROBLEM: How can we identify the composition of the atmosphere?

AIM: What is the composition of the atmosphere?

DEVELOPMENTAL STRATEGIES:

- Students will probably respond to motivation question with the names of some of the gases they know to be in the air rather than answering the "how" part of the question. Lead the students to understand that in order to discover that a particular gas is in the air, they must test for it. As an example, help them recall that for things to burn, oxygen is required; therefore, since things do burn, there must be oxygen in the air.

- Set up the demonstration. Soak the steel wool in vinegar for 10 minutes. (This can be done before class.) Rinse the steel wool, and push it into an empty test tube. Invert the test tube into a beaker of water, as in the following diagram.



- The students will see that the steel wool rusts by the next day. This uses up the oxygen in the test tube, and allows water to rise in the tube. It is important that they notice that the water rises about one-fifth of the way up the tube, showing that oxygen composes about one-fifth of the atmosphere.

- In the meantime, elicit the probable results from the students. Have them understand that this is a test to identify one gas, and that there are qualitative tests for other gases. Elicit the approximate composition of the atmosphere:

Nitrogen	78%
Oxygen	21%
Argon	less than 1%
CO_2	less than 1/20%

  Note that there are other gases in the atmosphere, but in very small amounts. Briefly discuss the greenhouse effect. (The addition of large quantities of carbon dioxide and water vapor to the air traps heat in the atmosphere, and causes the earth's surface to warm.) Some scientists are concerned that if this continues unchecked, enough heat can be trapped to melt the polar ice caps. Ask the students what effect this might have on them, since they don't live at the poles. (The slow melting of glaciers will cause the level of the seas to rise. The increase in air temperature will also affect the amount of rainfall and crop growth.)

- Ask the students if there is anything else besides gases in the atmosphere. They have previously studied dew point and relative humidity. Tell them that water comprises between 0 and 4% of the air on a given day, depending on weather conditions.

- Elicit that there are also solids in the atmosphere. Pollen grains, dust particles from volcanic eruptions, ashes from smokestacks, and other human-caused particles are all pollutants, and affect the atmosphere and life.

SUMMARY:

- The atmosphere is composed of a mixture of gases containing minute quantities of solid and liquid particles.

- The atmosphere is largely composed of nitrogen and oxygen.

- Carbon dioxide, although found in small amounts in the atmosphere, appears to have a significant effect on atmospheric temperatures.

- Water and water vapor can be found in the atmosphere.

- Many other substances can be found in the atmosphere, some occurring naturally and some as the result of human activity. Many of these can have effects on the atmosphere and on life.

HOMEWORK:

- Make a pie chart showing the percentages of gases in the atmosphere.

- Look around your neighborhood and list at least five things that add particles to the atmosphere.

- Make a list of the things that you do that can add particles to the atmosphere. How can you accomplish the same tasks without polluting?

ENRICHMENT:

- Another gas present in the atmosphere is ozone. Find out what it is, how it is generated, and why it is significant.

- Look up directions for making a simple air sampler. Bring in a sample of the particles found in the air and look at them under the microscope. Report on your findings.

- Find out about acid rain. What is it, why should we be concerned about it, what causes it, and how can it be curtailed?

LESSON 13

TOPIC: Layers of the atmosphere

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E/III B3

PROCESS SKILLS: 2

AIM: What are the characteristics of the layers of the atmosphere?

MATERIALS:

- a transparency of the Reference Sheet

PERFORMANCE OBJECTIVE: Students will be able to:

- summarize the major characteristics of the layers of the atmosphere.

MOTIVATION:

- Ask the students how many of them have flown in airplanes, and if so, at what altitude the plane flew.

PROBLEM: How can we explain why pilots prefer to fly in one part of the atmosphere rather than another? What are the differences between them?

AIM: What are the layers of the atmosphere?

DEVELOPMENTAL STRATEGIES:

- Discuss reasons why pilots prefer to fly in the the stratosphere (because of the absence of weather).

- Display the transparency of the Reference Sheet. Have students locate the layers of the atmosphere and the heights of the layers.

- The information below outlines the key information to be dealt with in class:

  - Troposphere: a layer of decreasing temperature which varies in height depending on the temperature at the surface of the earth. Since almost all of the water in the atmosphere is located in the troposphere it is the only layer that has "weather." (Some water occurs in noctilucent clouds, which are found in the stratosphere. Water is also present in minute amount to the limit of the atmosphere.) Students should realize because of their experiences with mountains, or even pictures of mountains, that it gets colder as you rise in the troposphere.

- Stratosphere: clear and dry with gradually increasing temperatures. The ozone layer is located within the stratosphere. Discuss the role of ozone in protecting us from the ultraviolet rays of the sun. Bring in the damage done by fluorocarbons in aerosol spray cans and its effect on the ozone layer.

- Mesosphere: region of falling temperatures.

- Thermosphere: temperatures rise again. Within the thermosphere is the ionosphere, a region of ionized gases. Discuss with students the role of the ionosphere in radio- and TV-wave transmissions.

. Bear in mind that the specifics are less important than the whole; what is important for students to understand is the layered nature of the atmosphere.

SUMMARY:

. The atmosphere is composed of several layers.

. The layers of the atmosphere can be distinguished by their properties.

. The properties of the layers change with altitude.

HOMEWORK:

- Draw a diagram of the layers of the atmosphere, and label each of the layers.

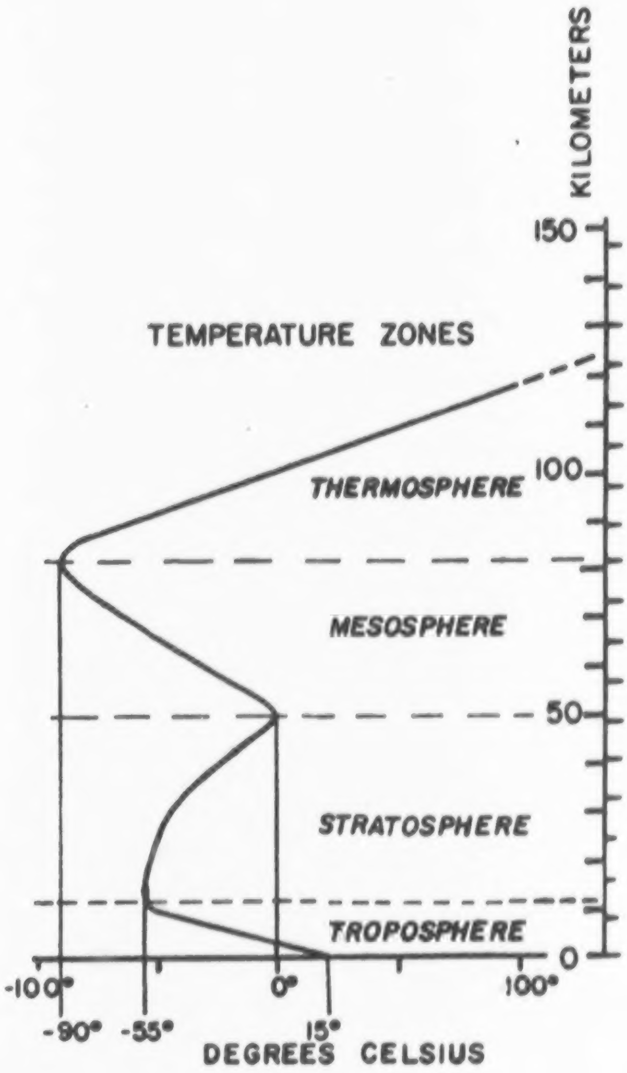
- How and from what does the atmosphere protect us?

- Why do you think that most of the gases in the atmosphere are found well within the troposphere?

ENRICHMENT:

- Tune in a radio three hours after sunset. Write down the number of each station you can receive, and the city from which it broadcasts. Try it again with the same radio the next day during daylight hours. Do you get all the same stations both times? Why or why not? What do you think the atmosphere has to do with this?

- Research the hole in the ozone layer. Report to your class.


KILOMETERS
150
100
50
0
TEMPERATURE ZONES
THERMOSPHERE
MESOSPHERE
STRATOSPHERE
TROPOSPHERE
-100°
0°
100°
-90°
-55°
15°
DEGREES CELSIUS

LESSON 14

TOPIC: Atmospheric pollution

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E11, I15, I16, I19

PROCESS SKILLS: 1, 2, 5, 14

AIM: What determines whether or not a substance is an air pollutant?

MATERIALS:

- matches
- candle
- volatile substance (e.g., ammonia, an aerosol deodorant)

PERFORMANCE OBJECTIVES: Students will be able to:

- define air pollutant.
- give examples of several types of air pollutants.
- summarize the types of air pollutants and their causes.
- interpret the results of a simple demonstration.

MOTIVATION:

- Many concrete examples can be given of air pollution on a small scale. Several such examples should be observed and discussed. Using these examples as a basis, students should be encouraged to discuss the various aspects of pollution on a large scale.
  - What are some of the effects of combustion on the composition of the air? Light a candle and hold an aluminum can cover or glass plate several inches above the flame. Observe what is deposited on the object held over the flame.
  - What can scent tell us about the characteristics of the air in the room? Open a can of a volatile substance, such as ammonia or a room deodorizer, in the classroom. **CAUTION: Do not use any substance that could cause a health hazard, e.g., carbon tetrachloride.**
  - What are some of the products of incomplete combustion? (CO_2, CO, H_2O, etc.) Discuss the exhaust systems of automobiles.

PROBLEM: How can we examine some atmospheric (air-borne) pollutants and analyze their effect on living things?

AIM: What determines whether or not a substance is an air pollutant?

DEVELOPMENTAL STRATEGIES:

. Refer to the candle demonstration, and ask the students what caused the residue on the glass plate. Elicit that burning the candle produced a substance that was introduced into the atmosphere. This substance, if introduced in large quantities, would have an adverse effect on living things.

. Ask students if they have observed any situations in their neighborhood similar to that of the residue deposited by the burning candle. Elicit that soot and ashes are introduced into the atmosphere through chimneys, incinerators, and fires. These are the results of human acts.

. Point out that forest fires and natural disasters like the eruption of Mount St. Helens also introduce soot and dust particles into the air.

. Refer to the volatile substance demonstration and elicit that volatile materials like aerosols contribute to pollutants in the air. This kind of pollution can be modified by humans in an attempt to eliminate it from the atmosphere. For example, fluorocarbons have been outlawed as aerosol propellants.

. Elicit that contaminants, regardless of their source (natural or man-made), are considered pollutants.

. Ask the question: "If pollutants are harmful, then why are they allowed to be produced?" Elicit that in today's technological society, pollutants are unavoidable.

. Challenge the class to devise a plan to control pollution. Accept several reasonable responses and tell the class that the government has been doing the same job through governmental agencies in an attempt to determine acceptable standards and to ensure compliance. Ask the class to list several more types of atmospheric pollution: car exhaust, factory smokestack ashes and other residues, etc.

SUMMARY:

. Substances found in the atmosphere, both as the result of human activity and natural events, can have adverse effects on humans, animals, vegetation, and materials. Undesirable substances in the atmosphere, regardless of origin, are called contaminants. Air pollutants can be products of natural or human activity.

. Air pollutants include undesirable gases, liquids, and solid particles such as carbon monoxide, sulfur dioxide, incompletely burned rubbish, and "smog."

. Technological pocesses can be modified to overcome the damage they cause.

. Nature can contaminate the atmosphere. Examples include pollen, dust, volcanic ash, and the combustion products of forest fires.

- The atmosphere plays a major role in dispersing toxic and harmful substances resulting from human activity and natural events.

- Practically every activity releases some contaminants into the atmosphere. Consequently, air pollution will never be eliminated. The purpose of air pollution control is to reduce air pollution to acceptable levels.

- Governmental agencies, industry, and people in the community are responsible for determining acceptable air quality standards and for taking steps to assure compliance.

HOMEWORK:

- Observe and record at least five sources of atmospheric pollution in your immediate environment.

- How could you control or reduce the pollution you observed?

ENRICHMENT:

- Solid particles in apparently dust-free air may be collected and analyzed. Cover a small glass plate, floor tile, or any similar convenient movable surface with a thin layer of a sticky substance, such as vaseline, agar, or dessert gelatin. Expose the plate to the atmosphere for a day and then examine the surface under a dissecting microscope. If the exposure is made during warm months, pollen and other organic "dust" will be identifiable on the plate. A surprising quantity of inorganic particles from the seemingly clean atmosphere will adhere to the plate. (These particles are much too large to serve as condensation nuclei.) Vary the height and location of the plate. Carry out the experiment in different seasons.

- Solid particles in the air can be collected on a filter attached to the hose of a vacuum cleaner. Tape or tie a piece of white cloth or paper towel to the open end of a large empty coffee can. Insert the end of the cleaner hose into a hole cut in the other end of the can. Seal the hose to the can with tape. Expose the end of the can with the filter to the atmosphere and turn on the cleaner. If the hose of the cleaner is removable, the filter may be placed directly over the intake hole. Carefully examine the filter at the end of an hour. Place clean filters on the can and collect other samples of atmospheric particles at different locations on different days. Compare the samples.

- Attempt to determine whether or not there appears to be a relationship between visibility and the number of particles collected, or if the height of the filter above ground level has any effect on the quantity of particles collected. What do these experiments imply as to the kinds and quantities of filterable particles in the atmosphere?

- Research other sources of pollution, e.g., different kinds of electromagnetic radiation, noise, radioactive materials.

LESSON 15

TOPIC: Energy in the atmosphere

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E12, E13, I23

PROCESS SKILLS: 1, 2, 3, 7, 12, 13, 14, 17

AIM: How is the atmosphere heated?

MATERIALS:

- radiometer
- lamp (or other suitable light source, e.g., a sunny window)
- two thermometers
- bunsen burner
- metal bar, long nail, etc.
- white sand
- dark sand or dry soil

PERFORMANCE OBJECTIVES: Students will be able to:

- identify the sun as the primary source of energy in the earth's atmosphere.
- explain that radiant energy received from the sun is transformed into heat energy and may be absorbed by the atmosphere.
- explain that energy which is not absorbed by the atmosphere is transmitted or is reflected back into space.
- identify those surfaces that are good reflectors and those that are good absorbers.
- explain how the atmoshpere is heated by conduction.

MOTIVATION:

- Demonstrate a radiometer by placing it in sunlight or exposing it to a lighted incandescent bulb. Have students study the vanes closely and record their observations. Elicit a possible explanation for their observations. (The dark vane moves away from the light source and the silvered vanes move toward the light source.)

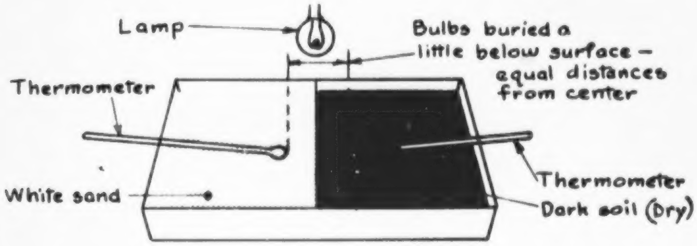
PROBLEM: How can we explain how light energy from the sun gets into the earth's atmosphere?

AIM: How is the atmosphere heated?

DEVELOPMENTAL STRATEGIES:

- Develop the concept that the dark vane warms more quickly than the silvered vane. The motion on the dark side pushes the vane away from the light source.

- Demonstrate how an increase in temperature increases molecular kinetic energy.
  - The dark vane warms more than the silvered vane because it is a better absorber of radiant energy.
  - The molecules of air in contact with the darkened vane absorb this energy by conduction and move away.
  - The vane is propelled forward because for every action there is an equal and opposite reaction.
- Point out that about half of the insolation (incoming solar radiation) reaches the earth's surface. The sunlight that does not reach the earth is either absorbed by the atmosphere or reflected back out into space.
- Demonstrate the effect of light on the dark soil and light sand surfaces. Set up the apparatus as shown in the diagram below. Have a student read each thermometer before the lamp is lighted. Record each temperature on the chalkboard. Read the temperatures at 15-minute intervals after lighting the lamp. Guide the students to conclude that the dark soil warms more than light surfaces.


Lamp
Bulbs buried a little below surface - equal distances from center
Thermometer
White sand
Thermometer
Dark soil (dry)

- Ask students which would add more heat to the air - the dark or light soil. From the demonstration, elicit that the dark soil would heat the air more. Point out that the light sand reflected the light energy better, before it could be changed into heat energy.
- Have a number of students take turns holding a metal rod in a bunsen burner until the rod just becomes warm. CAUTION: Be aware of the rate of warming of the metal rod to avoid burning the students.
  - Explain why the rod felt warm. (Objects feel warm to us because heat flows from a warmer object to a cooler until both are at the same temperature.)

. Write and define the words conduction, convection, radiation, and evaporation on the chalkboard.

- How does each of these methods of heat transfer affect air temperature? (The atmosphere is heated by warm soil mainly because the soil gives off infrared radiation which is absorbed by molecules of water, carbon dioxide, and nitrogen in the air. Conduction from the soil accounts for only a very small percentage of the heat-up.)

SUMMARY:

. The sun is the primary source of the energy of the atmosphere.

. The atmosphere is partially heated by direct solar radiation.

. The lower atmosphere receives most of its energy from solar energy which is absorbed by the earth's surface and then transferred to the atmosphere by radiation, evaporation (latent heat), convection, and conduction.

. The atmosphere loses energy to space by heat (infrared) radiation.

. The earth and its atmosphere radiate to space an amount of energy equal to that absorbed from the sun.

HOMEWORK:

- What is the primary source of energy in our atmosphere?

- How does the lower atmosphere receive most of its energy?

- What happens to energy that is not absorbed?

- What conditions make a surface a good absorber of radiant energy?

- Why is the atmosphere heated unevenly?

ENRICHMENT:

- Explain how weather arises.

. If time permits set up radiation apparatus (black and silver can) to further demonstrate how radiation is absorbed.

UNIT IV

LESSON 16

TOPIC: Air movements

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E14

PROCESS SKILLS: 1, 2, 5, 9, 12, 14

AIM: How do convection and radiation explain the movement of air in the atmosphere?

MATERIALS:

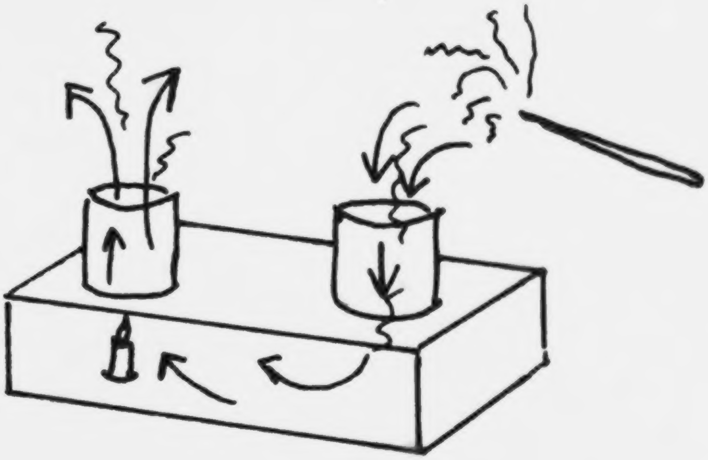
- convection box
- glowing splint, smoking piece of rope, or a "punk"
- heating coil
- glass plate
- piece of grid (e.g., window screen) cut to size of 35mm slide
- globe
- slide projector

PERFORMANCE OBJECTIVES: Students will be able to:

- define the terms radiation and convection.
- analyze a model of a convection cell and describe how it operates.
- compare the convection cell model to the movement of air in the atmosphere.
- describe the differences between cold air and warm air.

MOTIVATION:

- Display a convection box. Perform the following demonstration: light the candle under chimney 1 and place a source of smoke over chimney 2 (see illustration below). Observe the movement of the smoke and ask students why the smoke trail enters chimney 1 and exits chimney 2.



PROBLEM: How can we use the convection box demonstration to explain air movements in the atmosphere?

AIM: How do convection and radiation explain the movement of air in the atmosphere?

DEVELOPMENTAL STRATEGIES:

. Relate the convection box experience to the convection currents in a liquid. Elicit that when the air around the candle is heated, it expands and becomes less dense. Conclude that the denser, cool air pushes the less dense, warm air upward. This results in a convection current.

. To illustrate radiation, place a glass plate in front of an electric heating coil. Have students note that the visible light from the coil travels through the glass more readily than the infrared radiation. Use some familiar situations as examples, e.g., entering a closed automobile in the summertime after the car has been in the sunlight for several hours. Point out that the light waves pass easily through the glass, are absorbed by the materials inside the car, and are transformed into radiant energy. The temperature inside the car becomes greater than the outside temperature.

. Discuss the phenomenon known as the greenhouse effect. The atmosphere transmits short-wave radiation freely, but it traps the earth's long-wave radiation. It is mainly the water vapor concentration in the lower part of the atmosphere that acts similar to window glass. Water vapor is nearly transparent to sunlight entering the earth's atmosphere. However, the water vapor absorbs much of the long-wave radiation going out and coming in. The water vapor returns some of this radiation back to the earth's surface. Carbon dioxide in the atmosphere contributes also, but to a lesser degree than water vapor.

. Elicit that the air around us is heated by means of convection currents and radiation. Elicit that when the air near the surface of the earth is heated, it becomes less dense and is pushed upward by cooler, denser air.

. To illustrate how the angle of the sun's rays also affect the amount of heat energy absorbed by the earth, perform the following demonstration: project a 35mm slide with a piece of grid (window screen) on it onto a globe. Since the amount of light passing through each square of the grid is the same, the more spread out the light is on the globe's surface, the less concentrated it is.

. Because warm air is less dense than cold air, it weighs less per unit area. Therefore, warm air exerts less pressure than cold air. The uneven distribution of energy on the earth's surface (caused primarily by the angle of the sun's rays and the irregularity of the earth's surface) produces variations in temperature that result in differences in air density and pressure.

. Summarize the relationship between air temperature, pressure, and density.

SUMMARY:

- Atmospheric circulation is brought on by the unequal distribution of energy.
- The uneven distribution of energy in the lower atmosphere is primarily caused by the angle at which the sun's rays strike the earth and its atmosphere, and by the nature of the earth's surface.
- The uneven distribution of energy produces variations in air temperatures which result in variations of air density and pressure.
- Cold air is more dense than warm air. As a result, cold air sinks and pushes warm air up.
- Convection currents develop where cold air sinks, moves to a region of high temperature, and then pushes the warm air up.

HOMEWORK:

- In what three ways may air be heated?
- Why does warm air move upward?
- Where would you find the cooler air in your classroom?
- If you wanted to get proper circulation in your classroom, how would you adjust the windows? Why?
- How does a radiator heat your classroom by means of convection currents? Draw a diagram to show the path of the moving air.

ENRICHMENT:

- If time permits use a molecular diagram to illustrate why warm is less dense than cold air.

LESSON 17

TOPIC: Wind patterns

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E/E15

PROCESS SKILLS: 17

AIM: How does the air circulate around the world?

MATERIALS:

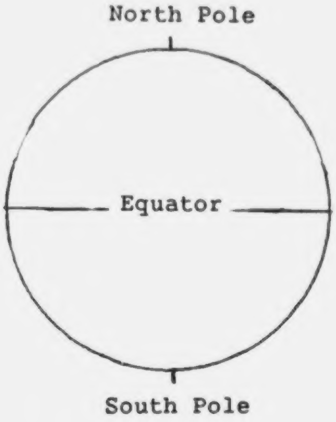
- map of the world
- globe or ball that can be marked with chalk
- copies or a transparency of the Reference Sheet (chart of winds)
- 250cm string or yarn

PERFORMANCE OBJECTIVES: Students will be able to:

- demonstrate how the world acts like an enormous convection system.
- explain why the rotation of the earth causes moving air to change direction.
- describe how the patterns of air movement affect the climate of the earth.

MOTIVATION:

- Draw the diagram below on the chalkboard and ask students where on this globe the winds would originate.



or

- Show students a map of the world. Indicate the path followed by Christopher Columbus. Ask students: "Why didn't Columbus follow the most direct route from Spain to America?"

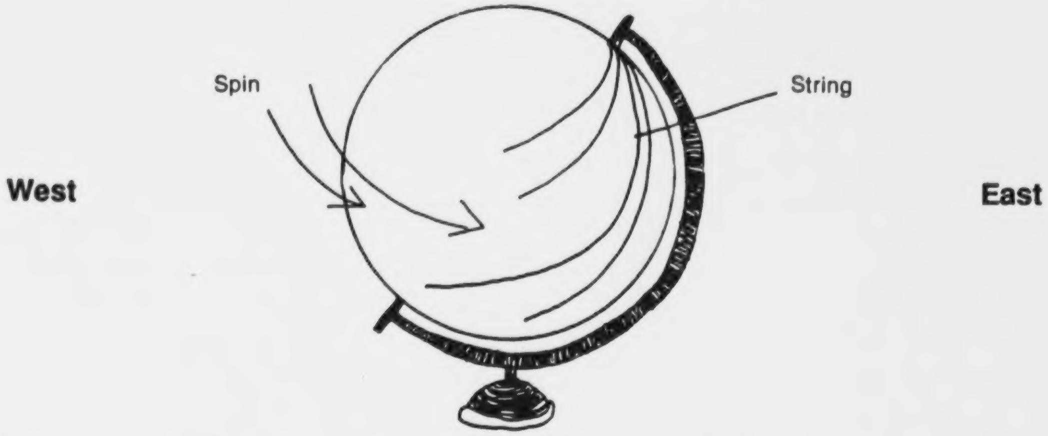
PROBLEM: Why do we have wind? Why do winds occur in predictable patterns?

AIM: How does the air circulate around the world?

INTRODUCTORY DEMONSTRATION:

The Coriolis Effect

- The deflection of winds due to the rotation of the earth can be demonstrated by using a globe and some string. Cut the string into ten 25cm lengths. Tape one end of each strand to the North Pole. Spin the globe in a west-to-east direction. The string (moving air) will be deflected to the right. This deflection is called the Coriolis effect.



- Deflection of winds to the left in the Southern Hemisphere can be illustrated by rotating the globe in an east-to-west direction and by assuming that you are looking down at the South Pole.

General Atmospheric Circulation

- In discussing atmospheric circulation and air masses, maps and globes that can be marked with chalk are particularly useful in representing the planetary wind system, ocean currents, air mass source regions and their paths, isobars, and isotherms.

- The map or globe can be profitably used in discussing such phenomena (and their causes) as:
  - continuity of pressure belts in the Southern Hemisphere and the lack of continuity in the Northern Hemisphere.
  - migration of pressure belts with seasons.
  - monsoons of India and of the Southeastern United States.
  - isobar and isotherm patterns in each hemisphere in a "summer" and "winter" month (isobars and isotherms are lines joining points of equal pressures and temperatures, respectively).

DEVELOPMENTAL STRATEGIES:

- Elicit that high temperatures are found in areas near the equator and low temperatures are found in areas near the poles.

- Recall the lesson on convection and develop the principle that cooler, denser air from the north and south will flow toward the equator, pushing the warmer, less dense air upward.

- Drip water on the top of a stationary globe and then on a rotating globe (turning counter-clockwise) and have students compare the stream of water on each globe.

- Relate the flow of the water to that of the air and develop the concept that, because of the rotation of the earth in the Northern Hemisphere, winds which blow from the north are deflected to the west and winds which blow from the south are deflected to the east. In the Northern Hemisphere, then, winds are deflected to the right and in the Southern Hemisphere the winds are deflected to the left.

- Distribute copies or prepare a transparency of the Reference Sheet showing wind systems on a rotating globe and discuss it.

- Explain the deflection by referring to Ferrel's Law explaining the relationship of the speeds of the winds as compared to the speed of the rotating earth at different points. ("A wind in any direction tends to deflect to the right in the Northern Hemisphere and to the left in the Southern Hemisphere with a force that is directly proportional to the mass of the wind in question, its velocity, the sine of the latitude, and the angular velocity of the earth's rotation.") Ferrel's Law can be demonstrated using a globe and some string as in the Coriolis force demonstration. Different gauges of string will show a change in force due to different masses. Spinning the globe with varying speed will show a change in force.

- Elicit some ways in which humans and the earth itself have been affected by the wind system. (Some examples are: the spread of early civilization assisted by trade winds, the formation of deserts in regions of the horse latitudes, and the differences in climate on the opposite sides of a continent.)

- With the aid of the Reference Sheet, develop the formation of a convection system between the equator and the horse latitudes.

SUMMARY:

- The rotation of the earth causes moving air in the Northern Hemisphere to appear to be deflected to the right; in the Southern Hemisphere, to the left.

- Forces arising from the earth's rotation and differences in the air pressure cause winds in the Northern Hemisphere to rotate clockwise (anticyclonic circulation), as viewed from above, around centers of high pressure and counter-clockwise (cyclonic circulation) around centers of low pressure--and vice versa in the Southern Hemisphere.

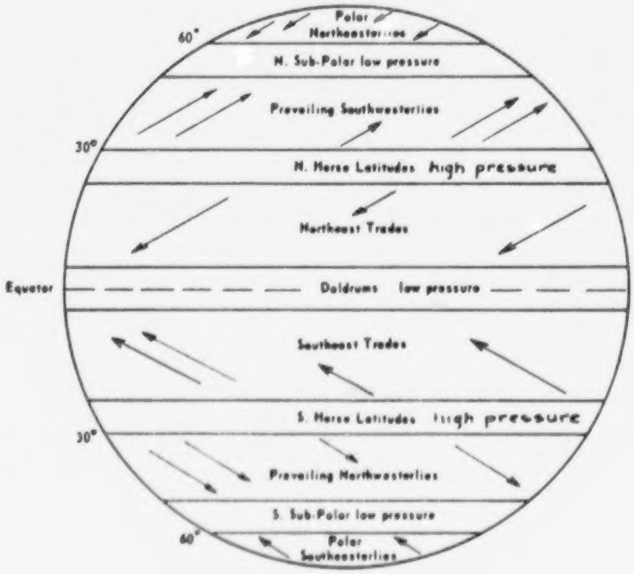
- The planetary temperature distribution and the effect of the earth's rotation result in worldwide pressure zones and large-scale wind belts. The wind belts result in a general (or averaged) pattern of air movement in the United States from west to east. However, from day to day and season to season, there is a great deal of north-south flow as well.

HOMEWORK:

- Why is the equatorial region a region of light wind?
- Why are winds deflected?
- Discuss two ways in which people have been affected by the global wind system.
- What might happen to a wind that crossed the equator from the north?

ENRICHMENT:

- Why does a convection current form between the equator and the poles?
- Why don't all winds blow north and south?
- Why are the earth's deserts found in the horse latitudes?
- Why is climate on the western side of the continent so different from the climate on the eastern side?


Polar
Northeasterlies
60°
N. Sub-Polar low pressure
Prevailing Southwesterlies
30°
N. Horse Latitudes high pressure
Northeast Trades
Equator
Doldrums low pressure
Southeast Trades
S. Horse Latitudes high pressure
30°
Prevailing Northwesterlies
S. Sub-Polar low pressure
60°
Polar
Southeasterlies

LESSON 18

TOPIC: Local winds

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E/E47

PROCESS SKILLS: 17

AIM: What causes some local winds?

MATERIALS:

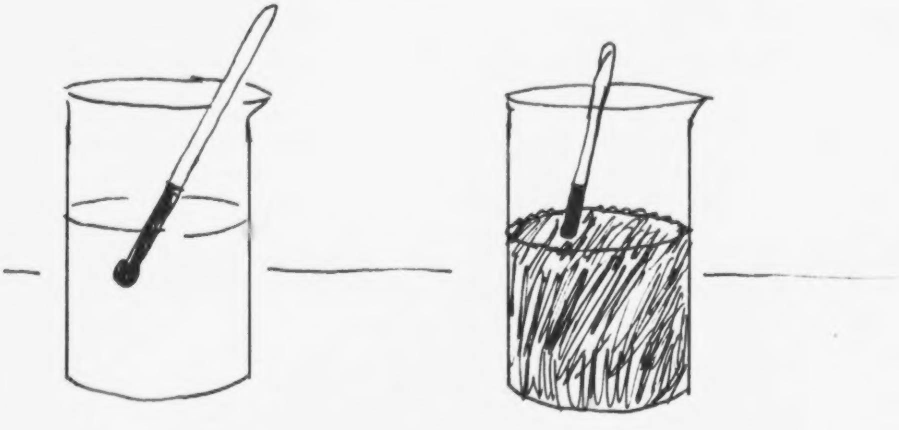
- two 600ml beakers
- soil
- ring stand
- two thermometers
- world map

PERFORMANCE OBJECTIVES: Students will be able to:

- identify the causes, locations, and effects of sea breezes, land breezes, mountain breezes, valley breezes, and monsoons.
- explain how local winds relate to temperature differences between the land and nearby water and ocean currents.
- explain why the land and nearby water differ in temperature.

MOTIVATION:

- Set up the following demonstration to show the unequal heating of land and water. Place some soil in one beaker and fill the other to the same level with water. Support a thermometer in each beaker with the bulb covered, as shown in the diagram below. Allow the containers to remain in a shaded place until their temperatures are the same. Then set the beakers in direct sunlight.



- Read the thermometers every ten minutes during a class period and determine which gains heat faster. Relate the results to the development of land and sea breezes.

- This process can be speeded up by substituting a light source for the sunlight (use a 100watt bulb and a reflector) and taking readings every minute for ten minutes.

- Elicit from students why there is usually a breeze at the beach in the summertime.

PROBLEM: Why does it get windy?

AIM: What causes some local winds?

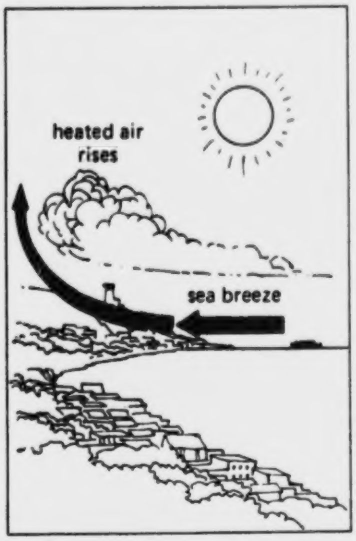
DEVELOPMENTAL STRATEGIES:

- Remind students that the land heats faster than the sea in the daytime.

- Recall the fact that the air over the land is lighter (and the pressure consequently less) than the air over the sea.

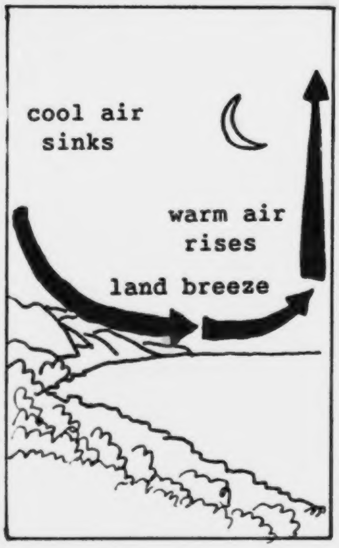
- Elicit that a convectional system has been set up between the land and sea with the breeze blowing from the ocean. Why?

- **Tell the students that the breezes are named for their sources. Identify the breeze as a sea breeze. Have them copy the diagram below.**



- Use the same process for the nighttime, eliciting these facts:

  - Land cools faster than water.
  - Air over land is cooler (and the pressure greater) than air over the sea.
  - Wind now blows from the land to sea.
  - This type of breeze is called a land breeze.



- Apply similar reasoning to help students understand the causes of valley and mountain breezes.

- Refer to a world map or globe. Elicit that in the regions near the equator there is little daily temperature change in both land and sea. Develop the fact that the sea and land maintain the same relative pressure.

- Developing the idea that temperatures north and south of the equator are different from temperature at the equator, guide the students to conclude that the convectional system is now on a seasonal rather than on a daily basis.

- Have the students develop the direction of wind during the summer and winter. Draw a rough diagram on the chalkboard.

- Identify the monsoon as this type of seasonal wind.

SUMMARY:

- Temperature differences across coastlines can produce sea breezes by day and land breezes by night.

- Sea breezes, land breezes, valley breezes, and mountain breezes are local winds.

- Monsoons are seasonal winds.

HOMEWORK:

- When does a sea breeze change to a land breeze?

- Why is a sea breeze a local breeze?

- What is the effect of both the land and the sea being at the same temperature?

- What would happen if the land did not cool at night?

ENRICHMENT:

- Why does a sea breeze usually blow during the daytime?

- How does a sea breeze differ from a moonsoon wind?

- Why are the special winds usually local in nature?

- Report on the importance of local winds to resorts and agriculture.

LESSON 19

TOPIC: Cloud formation and precipitation

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E/E17

PROCESS SKILLS: 1, 2, 3, 4, 5, 6, 9, 11, 12, 13, 14, 17

AIM: How are clouds/fog formed?

MATERIALS:

- 2 metal cans
- water
- crushed ice
- Celsius thermometer
- bunsen or alcohol burner
- drinking glass
- 250mL Florence flask
- ink blotter
- aquarium with lid
- thick-walled glass jar
- hygrometer
- battery jar
- 250mL Erlenmeyer flask
- glass tube or soda straw
- wooden match
- old-fashioned milk bottle
- narrow-mouthed glass jar
- nylon stocking
- embroidery hoop
- powdered sugar
- dry ice

PERFORMANCE OBJECTIVES: Students will be able to:

- define the terms condensation nuclei, clouds, sublimation, and precipitation.
- explain how water gets into the air and condenses.
- design a laboratory lesson demonstrating condensation.

MOTIVATION:

- There are many ways cloud and precipitation formation can be introduced.

  - Ask students to observe clouds outside the classroom.

  - Ask students what causes a mirror to fog up after they have taken a hot shower.

  - Ask students why it can't rain unless there are clouds.

PROBLEM: What causes clouds and precipitation?

AIM: How are clouds/fog formed?

DEVELOPMENTAL STRATEGIES:

. Pour ice and water into a metal can. If the humidity is not too low, moisture will collect on the can. Since the moisture cannot pass through the can, it must come from the air. Have students record the temperature of the ice water when the dew appears on the can. Define this temperature as the dew point temperature.

NOTE: On a very dry day there may be too little water vapor in the air for any to condense on the cold surface of the can. If this happens, set the can of water and ice in a large jar with a moist blotter in the bottom and cover the jar with pane of glass.

. Heat some water until it is near the boiling point. Pour the hot water into a drinking glass until it is about two-thirds full and rotate the glass so as to wet the sides all the way to the top. Now put some cold water into a Florence flask and set the flask on the glass at an angle. Water will evaporate from the surface in the glass and condense on the cold flask. Drops of the condensed water will continue to fall back into the glass for many minutes. This demonstration makes an extremely simple approach for developing the concept of the water cycle. Evaporation, condensation, and precipitation proceed inside the glass just as they do outside.

. Put a wet bottle into a large glass vessel such as an empty aquarium. Cover the vessel. In a few hours the humidity of the vessel will be high. Place a metal can of cold water in the vessel and note the condensation. Use a similar can of cold water outside the vessel as a control.

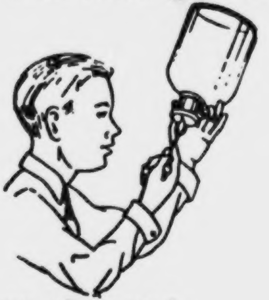
. Show students a piece of dry ice. Observe the decrease in size of the ice over the class period. Snow, ice, and frost can disappear in nature even when no "melting" occurs and the outside temperature remains below freezing. When a solid passes directly into the vapor phase without melting it is said to sublime.

. Place a thick-walled, clear glass jar in the freezer compartment for several hours (do this in advance). Remove to the room (or to a humid environment, as described above). Have students note the formation of rime ice (frost).

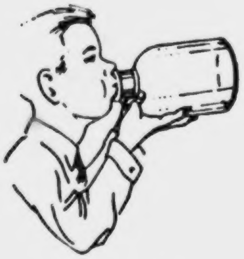
. Put a hygrometer in a large covered battery jar containing a piece of wet blotting paper. Warm the jar, then cool it. If the air is saturated, the wet and dry bulb readings should be the same at any temperature. Discuss the reason for this.

. Put a clean, dry Erlenmeyer flask in a cold place. Blow into the cold flask through a glass tube until a film of moisture forms on the inside. Then stopper the flask tightly and warm very gently. Observe what happens to the film of moisture. Place the flask in a cold place again and observe it periodically.

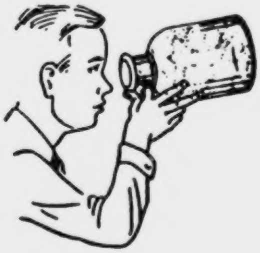
. Use the smoke from a match to "seed" the air inside a clear glass jug, as shown in the diagram below. Next, blow into the jug several times to raise the relative humidity. This, together with the suspended smoke particles, creates ideal conditions for condensation. Now, place the mouth of the jug against the lips; blow hard and release the pressure suddenly. The sudden release of the pressure cools the air slightly and a thick fog forms. Blow into the jug again and the fog disappears. It reappears when the pressure is again released. Try the same experiment without seeding the air in the jug with smoke particles.



Blow out the match and quickly place it in the mouth of the glass jug.

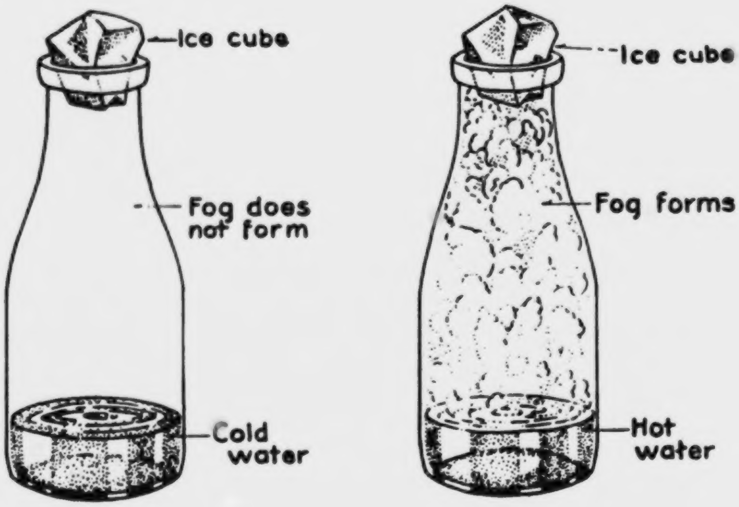


Blow into the jug several times.



Release the pressure suddenly.

. Fill an old-fashioned milk bottle with hot water. (A funnel and any 2L clear plastic or glass bottle can be substituted.) Then pour out most of the water, leaving about an inch in the bottom. Place an ice cube on the mouth of the bottle as shown in the diagram. Set up a control, using cold water instead of hot. Ask students to explain why fog forms in one bottle but not in the other.



NOTE: A funnel and any 2L clear plastic bottle can be substituted.

- A realistic measurement of raindrop diameters can be made by stretching a piece of nylon stocking over an embroidery hoop and sprinkling the fabric with powdered sugar. To obtain a sampling of raindrop sizes, hold the hoop horizontally for a few seconds outside during a period of rainfall until a number of raindrops have passed through the hoop. Quickly cover the hoop to prevent an overlapping of raindrop patterns. Indoors, an examination of the fabric will show markings in the sugar indicating where the drops passed through it. The diameters of these patterns are nearly the same as the horizontal diameters of the drops. Have students measure and record the average diameter of the drops. What were the extremes in diameters measured? If you assume that raindrops are spherical (they are not, but nearly so), what would be the average volume of the drops measured?

SUMMARY:

- At any given temperature, there is a limit to the amount of water vapor the air can hold. The higher the temperature, the more water vapor the air can hold.

- Air can become saturated by the introduction of more water vapor, through heat loss by radiation, through contact of air with cold surfaces, by the mixing of warm and cold air, and through cooling by expansion.

- Water particles form in the air by the condensation or sublimation of water vapor onto tiny particles of matter called nuclei.

- While various kinds of particles can act as nuclei, some particles are more efficient than others in bringing about condensation or sublimation.

- Clouds and fog are composed of minute water particles suspended in the air.

- Fogs are clouds in contact with the earth's surface.

- Clouds and fog will form only when the air is saturated and sufficient condensation nuclei are present.

- Dew is formed by the condensation of water vapor from the air directly onto objects.

- Frost is formed by the sublimation of water vapor directly onto objects.

- Cloud particles must be greatly enlarged if precipitation is to occur.

- The growth of ice crystals can result in cloud particles heavy enough to fall through the cloud, and sometimes from the cloud to earth.

- The type of precipitation, such as rain or snow, depends largely on the temperature of the air at the place of origin and through which it falls.

HOMEWORK:

- How does water get into the atmosphere?
- How does water come out of the atmosphere?
- Why does it rain?
- Explain, in terms of this lesson, why a person feels cooler on a hot, humid day when a breeze is blowing.
- A glass of water is put outside on a day when the dew point is very low. Will the water in the glass evaporate slowly or rapidly into the air? Explain your answer.
- A student collects raindrops, assigns them three sizes, and counts the number in each group. The results are as follows:

	VERY LARGE	LARGE	MEDIUM	SMALL
NUMBER OF RAINDROPS COLLECTED	40	30	20	25

- Display these results on a labeled graph.

ENRICHMENT:

- Design two simple weather instruments and use them to check for some of the atmospheric conditions discussed in this lesson.
- Pick a season. Predict average weather conditions at four cities in different parts of the world according to their location. Explain your predictions.

UNIT IV

LESSON 20

TOPIC: Climate: a definition

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E60

PROCESS SKILLS: 1, 2, 14, 15, 17

AIM: How does a desert climate affect the plants and animals that live there?

MATERIALS:

- map of the world
- photographs of desert plants and animals

PERFORMANCE OBJECTIVE: Students will be able to:

- define climate.
- name the climate zones.
- describe the relationship between climate and the types of plant and animal inhabitants in an area.

MOTIVATION:

- Display photographs of animals and plants that live in the desert (e.g., cacti, snakes, scorpions, insects).

- Ask the students to describe the life cycle of some of these creatures as well as their adaptations to desert life.

PROBLEM: How does climate affect the types of plants and animals that live in an area?

AIM: How does a desert climate affect the plants and animals that live there?

DEVELOPMENTAL STRATEGIES:

- Ask students to recall the different variables that produce weather. Be sure the discussion includes temperature, precipitation, barometric pressure, wind speed, wind direction, humidity, and warm and cold air masses.

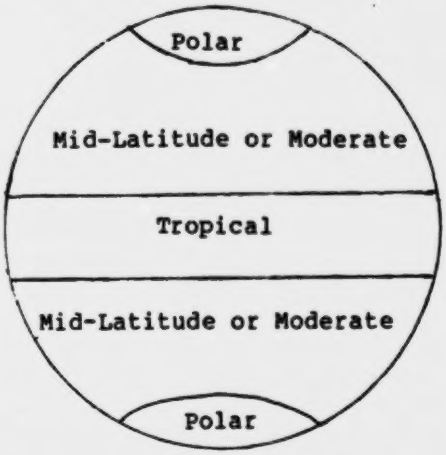
- Introduce the word climate and ask the students to differentiate between weather and climate.

- Elicit that climate consists of the average weather conditions in a region over a period of many years. Ask students to describe the different kinds of climates that are found on earth, i.e., very cold and snowy (polar), very hot and dry (desert), hot and steaming (tropical), and combination of hot and cold (moderate).

- Ask how the climate of New York City might be described. Elicit that New York City's climate is called moderate or mid-latitude because New York City has summer and winter.

- Display a map of the world and discuss the three basic climate zones found on earth.

- Have students copy the diagram below into their notebooks and label it using the three climate zones--tropical, moderate, and polar.



- Display the list below on the chalkboard and ask the students to write the names of the plants and animals in the areas where they live on their climate zone maps. Discuss their answers briefly.

polar bear
camel
saguaro cactus
lizard
road runner
deer
rattlesnake
monkey
alligator
kangaroo
oak tree
pine tree

- Ask students why there are different species of animals living in different areas of the world. Elicit that the climate dictates the types of animal that can live in a particular area. Discuss the reasons why.

- Indicate that the inhabitants of an area on earth are also influenced by their altitude above sea level.

- Have students imagine a mountain-climbing expedition that begins in a tropical rainforest at sea level and ends on a mountaintop 15,000 feet above sea level. Discuss the different types of climate zones that would be encountered on this journey.

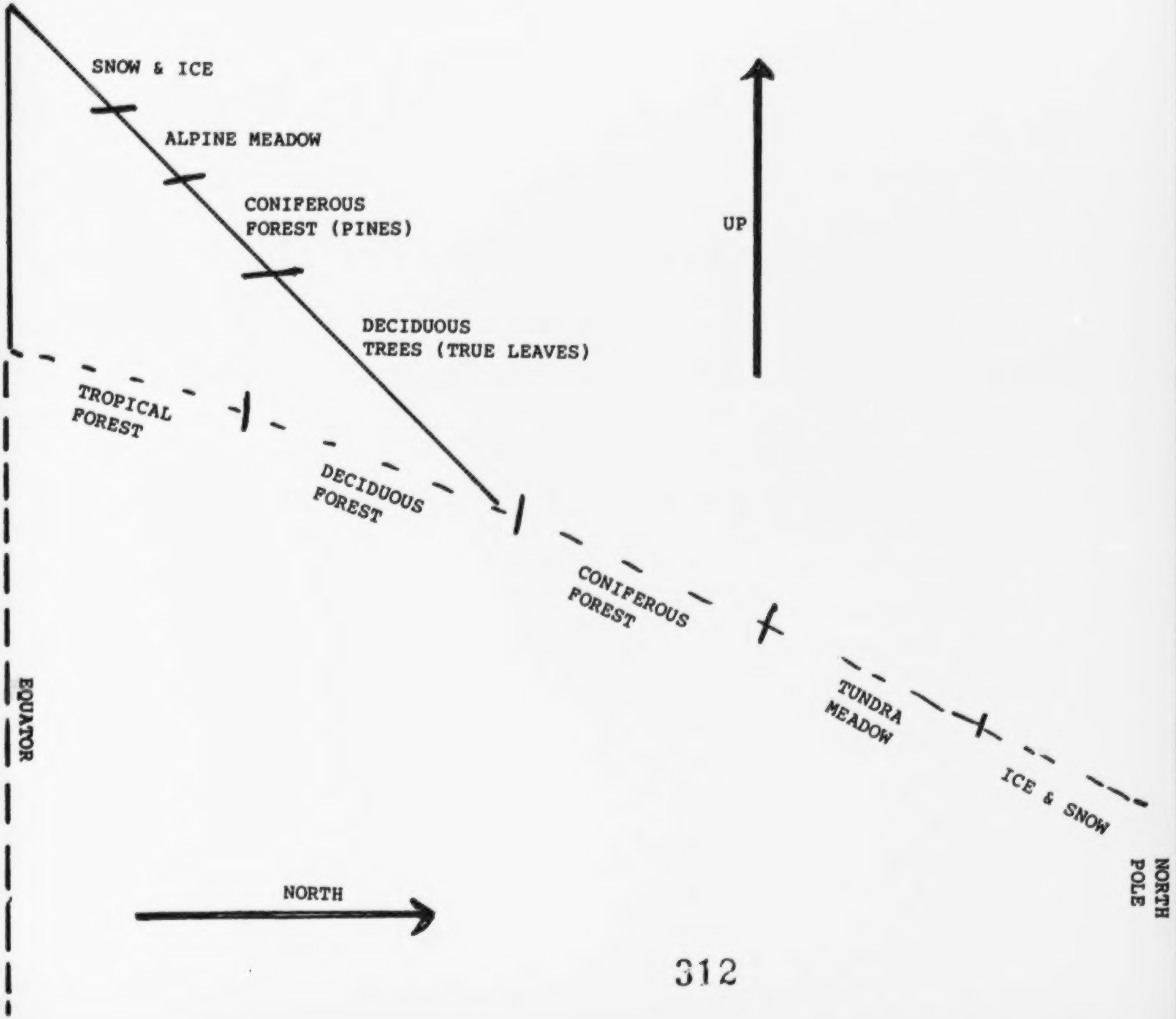
- Elicit that as one climbs a high mountain the air becomes increasingly colder. Plant and animal species tend to group themselves into distinct horizontal zones. Each 1,000 feet you ascend in altitude is equivalent to a trip of 300 miles northward from the equator. Place diagram (Reference Sheet) on the chalkboard (or display as transparency) to further develop this concept.

SUMMARY:

- Weather is a description of the atmosphere at a particular place during a short period of time.
- Climate is similar to weather except it lasts longer and usually covers a larger area.
- The earth is broken up into three basic climate zones--polar, tropical, and mid-latitude.
- Climate zones can also be found as one ascends high mountains.
- The climate of a region affects the types of plant and animal life that can live there.

HOMEWORK:

- Explain how the harsh climate of the desert affects the plants and animals that live there.
- Name two ways that weather is different from climate. How are they similar?
- Describe the similarities between traveling from the equator to the North Pole and ascending a 16,000-foot mountain at the equator.


SNOW & ICE
ALPINE MEADOW
CONIFEROUS FOREST (PINES)
DECIDUOUS TREES (TRUE LEAVES)
UP
TROPICAL FOREST
DECIDUOUS FOREST
CONIFEROUS FOREST
TUNDRA MEADOW
ICE & SNOW
EQUATOR
NORTH POLE
NORTH

UNIT IV

LESSON 21

TOPIC: General types of climate

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E/E19

PROCESS SKILLS: 1, 2, 11, 12, 13, 17

AIM: What factors influence climate?

MATERIALS:

- large U.S. map including mountain ranges
- prepared tables of various cities around the world with average temperatures, altitudes, latitudes, etc.

PERFORMANCE OBJECTIVES: Students will be able to:

- explain climate differences.
- show how topography, latitude, mountains, and bodies of water affect local climate.

MOTIVATION:

- Elicit from students why some people in New York go to Florida or the Caribbean in the winter. Elicit why people go to the mountains to ski. Elicit why desert temperatures can be very hot during the day but can freeze at night.

PROBLEM: What is the relationship between weather, geographic location, and climate?

AIM: What factors influence climate?

DEVELOPMENTAL STRATEGIES:

- Use actual temperature and climate conditions from various cities to illustrate how:
  - latitude affects climate (choose two cities at same longitude but one further north than the other).
  - altitude affects climate (choose two cities at the same latitude, one of which is at a higher altitude than the other).
  - bodies of water affect climate (choose inland and coastal cities at the same latitude).
  - mountains affect climate (choose two cities both at approximately the same latitude but one on the windward side of mountain and one on the leeward side).

SUMMARY:

- The climate of a region or place describes the characteristic weather that prevails from season to season and from year to year.
- Climate is described in terms of such factors as air temperature, humidity, rainfall, snow, ice, and sunlight.
- While many systems are possible, climate regions are most simply classified on the basis of temperature and moisture conditions.
- The climate of an area is a function of several interacting aspects including latitude, proximity to bodies of water, prevailing winds, ocean currents, and altitude.

HOMEWORK:

- What factors affect climate?
- Why is temperature range important in classifying climate?

ENRICHMENT:

- Make charts of low-, middle-, and high-latitude temperature zones. Describe types of climates in each and locations where each climate type would be found.

UNIT IV

LESSON 22

TOPIC: Effect of global winds on climate

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E/E44, E45, E46

PROCESS SKILLS: 1, 2, 8

AIM: What are the effects of the global winds on climate?

MATERIALS:

- large world map
- large globe (waterproof)
- beaker

PERFORMANCE OBJECTIVES: Students will be able to:

- explain the convection cycle that takes place in the atmosphere.
- demonstrate an understanding of the Coriolis effect.
- give examples to show that the global wind belts affect our climate.

MOTIVATION:

- Display a map of the world. Ask the students to locate the major deserts and the rainforests.

PROBLEM: How is it that major deserts and rainforests tend to occur in bands around the earth?

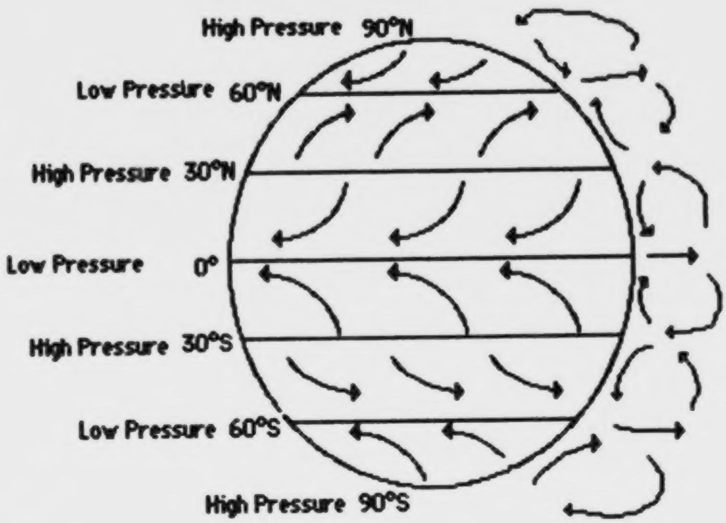
AIM: What are the effects of global winds on climate?

DEVELOPMENTAL STRATEGIES:

- Ask students why deserts and rainforests have developed.

- Elicit that the equatorial areas of the earth are generally the hottest. Review with students what they have learned about convection. At the surface of the earth in the equatorial zone, the temperature of the air is higher than it is at the surface of the earth in the high-pressure zones that border it to the north and south. Since the air temperature is higher, the air is less dense near the earth in the equatorial zone than it is in the bordering zones. The cooler, more dense air in the bordering zones pushes up the warmer, less dense air in the equatorial zone. As the air moves upward, it becomes cooler because it expands. Elicit what happens to air's ability to hold moisture when it cools. (It decreases.) Therefore, clouds form and it rains. The air continues to move upward until it reaches the upper limit of the troposphere. Then it moves horizontally until it reaches one of the high-pressure zones that borders the low-pressure zone.

- Begin developing a diagram of global wind belts on the chalkboard. You can use a transparency, but it is a good idea not to put more on the diagram than you have already discussed with the students, as this diagram can appear very complicated. One step at a time should make sense, and be less confusing. The completed diagram follows:



- In the high-pressure zones, the air is more dense near the surface of the earth, where it is cooler than in the low-pressure, equatorial zone. The total weight of a column of air (from the surface of the earth to the top of the troposphere) in the high-pressure zone is greater than the weight of a similar column of air in the low-pressure zone. This is why the air descends in the high-pressure zones and why it can push the air in the low-pressure zone upward and out of the way. As the air falls in the high-pressure zones, it becomes warmer because it is compressed by the weight of the air above it. It is dry air because the moisture precipitated out as rain when the air was rising in the low-pressure zone. This hot, dry air in the high-pressure zone can hold a great deal of moisture and it causes evaporation of moisture from the surface of the earth. Elicit that these are the areas where students located the deserts earlier in the period.

- Continue the pattern by building the wind belts between the 30° and 60° latitudes and between 60° and the poles. Students should understand that rising belts are belts of low pressure, and that where there are belts of high pressure the air falls.

- Now discuss the winds as they blow across the surface of the earth. Remind the students of the demonstrations of the Coriolis effect from Lesson 17. (OPTIONAL: Demonstrate the Coriolis effect. Tell the students that since we cannot see the wind, you are going to demonstrate wind using water. [The analogy is valid, as they have many of the same properties.] Use a large globe on a stand, and a beaker of water. Ask students what will happen if you pour some of the water on the globe from the North Pole. Demonstrate, and let it dribble straight down. Now show them what really happens with a rotating earth. Have a student volunteer spin the globe rapidly while you pour water on the North Pole of the globe. Stop the globe after a few seconds and have the class notice the path of the water as it moved down the globe. [It will have been deflected toward the right.] Elicit that the same thing happens with the winds on the earth.)

- Elicit from the students that our section of the earth is between 30° and 60° north latitude. Lead them to realize that the direction of the winds due to the Coriolis effect is what drives our weather from west to east across the United States.

SUMMARY:

- Large convection currents exist in the atmosphere due to unequal heating of the earth.

- These convection currents result in different climates for different latitudes of the earth.

- Due to the rotation of the earth, global winds are deflected toward the right in the Northern Hemisphere, and toward the left in the Southern Hemisphere.

HOMEWORK:

- What causes winds?

- Explain why the deserts of the world are located approximately 30° north and south of the equator.

- At home, pour some water from a narrow-mouthed bottle into a glass from a height of about 1 foot. Record your observations. Put a stopper in the sink and run about 2 inches of water into the basin. Remove the stopper to let the sink drain and record your observations. Now flush the toilet and record your observation. Do you see any similarities among those three tasks?

ENRICHMENT:

- Find out departure and arrival times when flying from New York to Los Angeles, California. Find out departure and arrival times when flying from Los Angeles back to New York. Explain the difference.

- Find out about the terms "doldrums" and "horse latitudes." What do the words mean and how do they relate to climate on the earth?

UNIT IV

LESSON 23

TOPIC: Factors affecting temperature

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E

PROCESS SKILLS: 1, 2

AIM: What factors affect the temperature of a location?

MATERIALS:

- large world map
- Student Worksheet

PERFORMANCE OBJECTIVES: Students will be able to:

- list the factors that affect temperatures on the earth.
- give examples of locations in the United States that are affected by these factors.

MOTIVATION:

- Distribute copies of the Student Worksheet (a map of an imaginary continent). Ask the students how they could begin to figure out the comparative temperatures of the cities on the map.

AIM: How can two cities with the same coordinates have different climates?

PROBLEM: What factors affect the temperature of a location?

DEVELOPMENTAL STRATEGIES:

- Refer to the map of the imaginary continent. (These same maps will be used again in the next lesson.) Ask students if there are any cities on the map whose temperatures they can describe. They should be able to tell you that City A would be hotter than any other city since A is closer to the equator. City C will be colder since it is further away. You can refer to a world map and compare these imaginary cities to real ones, if you wish.

- Note that cities A, B, and C are on the same line of longitude, and far from the effects of a large body of water. (Students should be guided to compare only one variable at a time.)

318

- Now turn the students' attention to cities B and D. Note that City D is located at the approximate latitude of New York City. Ask how they think the temperatures of these two cities compare. If they have trouble, tell them to pretend that D is New York and that B is Omaha, Nebraska. Give them the yearly temperature extremes for both cities.

	Normal High, July	Normal Low, January
New York, NY	81°F	25°F
Omaha, NE	88°F	13°F

Let the students subtract to determine the temperature range and have them see that the temperature range of City B (Omaha) is much greater than the range of City D (New York). Ask them why they think the range of temperatures is 75 degrees in City C but only 56 degrees in City D. Lead them to understand the moderating effect of the ocean on the temperatures of coastal cities.

- Now call their attention to cities E and F. They should understand that City F is on the side of the mountain range, which means that it is at a higher altitude. Remind the students what happens to the temperature when they go up the side of a mountain. Students should be able to recall scenes of people skiing during the summer on high mountains.

- Another factor, not shown on the imaginary continent, is the effect of ocean currents. Have students find England on the world map and note that it is at a much higher latitude than New York City. The average temperatures in London range from 72°F in July to 36°F in January. Point out that the mildness of British winters is due in part to the nearness to water, but that it is also due to the Gulf Stream, which brings warming waters from the more southerly areas of the Atlantic Ocean. (In the early 1980s there was a sudden freak snowstorm in England and the airport had to be closed because of 2 inches of snow. Until recently houses were built without central heating and without air conditioning. There is no real need for either.)

SUMMARY:

- Temperature is affected by latitude. In general, the higher the latitude, the lower the temperature.

- Temperature is affected by altitude. In general, the higher you go up a mountain, the lower the temperature.

- Temperature is affected by nearness to water.

- Temperature is affected by ocean currents.

HOMEWORK:

- List three factors that affect the temperature of an area.

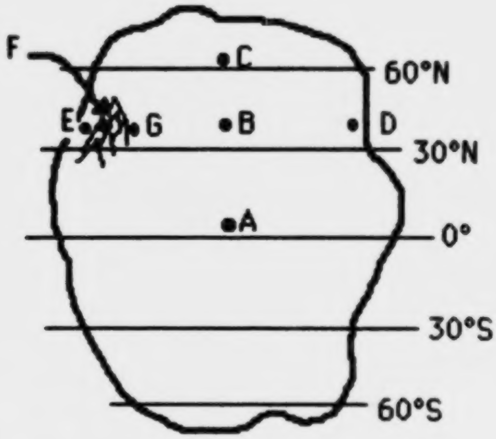
- Give two reasons why the temperature range in England is lower than might otherwise be expected.

- Which of the cities on the imaginary continent do you think would be most affected by seasonal changes, and which least affected. Why?

ENRICHMENT:

- Using an almanac or other reference book, look up the temperature ranges in various cities around the country. Get an outline map of the United States, and put these on the map.
- Design an experiment to test the statement that cities near the equator are warmer than those further away.
- Using an atlas, locate the major ocean currents. List some cities that you think are affected by each current, and how they are affected.

Map of an Imaginary Continent


F
C
60°N
E
G
B
D
30°N
A
0°
30°S
60°S

LESSON 24

TOPIC: Factors affecting moisture

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E17

PROCESS SKILLS: 1, 2, 14

AIM: How can two cities with the same coordinates have different amounts of precipitation?

MATERIALS:

- large world map
- student maps of imaginary continent from the previous lesson
- large pictures (such as travel posters) from the state of Washington showing rainforests
- map of the state of Washington

PERFORMANCE OBJECTIVES: Students will be able to:

- list the factors that affect moisture on the earth.
- give examples of locations in the United States that are affected by these factors.
- explain the role of mountains in modifying climate.

MOTIVATION:

- Show students the pictures of the rainforests in Washington State. Tell them that parts of Washington receive up to 200 inches of rain a year, while other parts of the state get as little as 15 inches of rain a year. Ask them what they think could determine the amount of moisture an area receives.

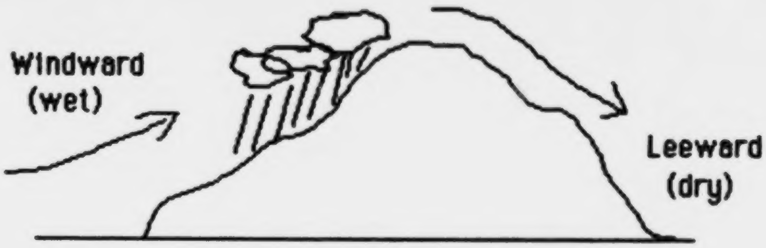
PROBLEM: What factors affect the amount of moisture in a location?

AIM: How can two cities with the same coordinates have different amounts of precipitation?

DEVELOPMENTAL STRATEGIES:

- Show the class a map of Washington. Tell students that the rainforests in Washington are in Olympic National Park; the dry spots are around the city of Spokane. The students should realize that the mountains must play a role in determining the amount of rainfall.

- Develop the following diagram on the chalkboard:



- Indicate that winds blowing in off the Pacific Ocean are rich in moisture. When the wind hits the mountains, it has nowhere to go but up, causing it to cool by expansion. As this happens, the air reaches its dew point, and it will eventually rain. The air then proceeds down the other side of the mountain, but now it is dry. It warms up by compression and any moisture on the leeward side evaporates. Elicit that this is what happens in the Rocky Mountains and that the great deserts of the United States are located just east (leeward) of the Rockies.

- Have students take out the map of the imaginary continent that they were introduced to in the previous lesson. Ask students which of the cities on the map could represent the leeward/windward condition. Have them analyze the climate of each of the cities on the imaginary continent in terms of moisture.

- Elicit from the students what they learned earlier about high- and low-pressure belts. Remind them that City A is in a low-pressure belt (this will make it moist), and that 30° N represents a high-pressure belt, so depending on how close to the 30° line cities B, D, E, F, and G are, their climate may be affected.

- Another factor that influences moisture is distance from a large body of water.

SUMMARY:

- The amount of moisture an area receives is affected by its proximity to water, the prevailing wind belts, the proximity to mountains, and the side of the mountain on which it is located.

- Deserts are frequently found on the leeward sides of mountains.

HOMEWORK:

- Give a description of at least one way mountains can affect the climate of a city.

- List each of the cities (A-G) on the imaginary continent and describe each climate in terms of temperature and moisture. Give a reason for your choice in each case.

ENRICHMENT:

- Using what you have learned, figure out why the rains on the western side of the Cascade Mountains are greater than the rains on the western side of the Appalachian mountains.
- Find out what is meant by a water budget. Explain how you can describe the climate of a city if you are familiar with its water budget.
- Find out about the prehistoric climate of the United States. Report on this to the class, including examples of proofs that we have.

UNIT IV

LESSON 25

TOPIC: Climate of New York State

STATE BLOCK REFERENCE/CORE UNDERSTANDINGS: E/E60, E61

PROCESS SKILLS: 17

AIM: What is the climate of New York State?

MATERIALS:

- map of New York State geographic features
- climate map of New York State region
- map of New York State growing season
- Student Worksheet

PERFORMANCE OBJECTIVES: Students will be able to:

- analyze the climate of New York State.
- compare the climate of New York City to an inland city at similar latitude.
- show how the geography of New York State affects its climate.

MOTIVATION:

- Ask the class where in New York State they would like to vacation this summer. Answers will vary but most will select the mountains or the beaches, because of the relief from the heat.

PROBLEM: Why is the climate in New York State different from place to place?

AIM: What is the climate of New York State?

DEVELOPMENTAL STRATEGIES:

- Elicit what the climate is like in various parts of New York State during different seasons.

- Display a map of New York's geographic features. Call attention to the features that influence local conditions. Include large bodies of water such as Lake Erie and Lake Ontario, the Atlantic Ocean and Long Island Sound. Also include altitude influences such as the Allegheny Plateau, the Catskill Mountains, and the Adirondack Mountains.

- Discuss the climate of New York City. Ask students how being located near the Atlantic Ocean affects our climate. Discuss the moderating affect of the ocean and compare NYC's summer and winter temperatures with those of any inland city at the same latitude.

. Daily radio and television roundups and newspaper weather maps give further evidence of varying conditions over the state. Display and discuss information obtained from these sources.

. Ask students how the climate in various parts of New York affects the growing season. If possible, display a map showing the length of the growing season and show variations in climate. (These may be obtained from a local greenhouse.)

. Distribute copies of the Student Worksheet and instruct students to complete the chart. After completion, discuss their results.

SUMMARY:

. New York State has a humid continental climate with moderate rainfall, hot summers, and cold winters.

. Climate in New York State varies considerably with location.

HOMEWORK:

- What differences are there in various parts of New York State between winter and summer temperatures?

- What are the characteristics of the New York State climate?

- How does the Atlantic Ocean affect the climate of New York State?

ENRICHMENT:

- Find out how human activity affects New York State's climate.

UNIT IV
Lesson 25

STUDENT WORKSHEET

NAME ______________________________ CLASS __________ DATE ____________

Factors Affecting N.Y.S. Climate	Description	Example of Area Affected by This Factor
Coastal		
Mountains		
Lake		
Latitude		
Air Masses		
Human Activity		

EVALUATION FORM

EIGHTH GRADE EARTH SCIENCE

Since Eighth Grade Earth Science--Part I is new and experimental, we need your suggestions and support so it can be revised into a more complete form.

Please answer the questions below as completely as you can, assured that your reactions will be much appreciated and given most respectful consideration in compiling the revised edition. Please send your completed evaluations to:

Dr. Anthony A. Galitsis, Director of Science
Board of Education of the City of New York
Science Unit - Room 414A
131 Livingston Street
Brooklyn, New York 11201

NAME: ______________________________ SCHOOL ____________________

SCHOOL ADDRESS: ______________________________

NUMBER OF STUDENTS PILOTING COURSE: ______________________________

ABILITY LEVEL OF STUDENTS: ______________________________

1. Are the goals of this course of study clear? yes _____ no _____

Explain: ______________________________

2. Does this curriculum meet your students' needs? yes _____ no _____

Explain: ______________________________

3. Is the format of this course of study useful? yes _____ no _____

Explain: ______________________________

4. Is this course of study well organized? yes _____ no _____

Explain: ______________________________

5. Would you make any changes in the types of learning activities presented in this course of study? yes _____ no _____

Explain: ______________________________

6. Did the suggested activities enable the students to achieve the performance objectives? yes ______ no ______

Explain: ____

7. Did any of the suggested laboratory activities cause problems? yes ______ no ______

Explain: ____

8. Do you think there will be any difficulty in implementing this course? yes ______ no ______

Explain: ____

9. What additions, deletions, or changes in sequence would you recommend for each unit?

____

10. What changes would you make to improve the quality of this document?

____

11. Do you have any additional comments?

____

It is the policy of the New York City Board of Education not to discriminate on the basis of race, creed, national origin, age, handicapping condition, sexual orientation, or sex in its educational programs, activities, and employment policies, as required by law. Any person who believes he or she has been discriminated against should contact the Local Equal Opportunity Coordinator, Division of Curriculum and Instruction, 131 Livingston Street, Brooklyn, New York 11201. Inquiries regarding compliance with appropriate laws may also be directed to Mercedes A. Nesfield, Director, Office of Equal Opportunity, 110 Livingston Street-Room 601, Brooklyn, New York 11201; or to the Director, Office of Civil Rights, U.S. Department of Education, 26 Federal Plaza, Room 33-130, New York, NY 10278.